Reference Manual
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Rosemount Process Radar in Power Applications

Best Practices User Guide

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Process Management

Rosemount Process Radar in Power Applications

Best Practices User Guide

⚠ CAUTION

The products described in this document are NOT rated for use in nuclear-qualified applications.

Using non-nuclear qualified products in applications that require nuclear-qualified hardware or products may cause failure of the device.

For information on Rosemount nuclear-qualified products, contact your local Emerson Process Management Sales Representative.

The Guided Wave Radar (GWR) products (Rosemount 5300 and 3300 Series) are designed to meet FCC and R&TTE requirements for a non-intentional radiator. It does not require any licensing whatsoever and has no tank restrictions associated with telecommunications issues.

For Non-intentional radiators (Rosemount 3300 and 5300 Series), the Rosemount products are compliant with EMC Directive 2004/108/EC.

The Non-contacting radar devices comply with part 15 of the FCC rules. There are no restrictions for use of the Rosemount 5401 low frequency device. The high frequency Rosemount 5402 may be used in any type of vessel. The mid-frequency Rosemount 5600 Series must be used in metallic vessels. If the device is to be used in an open air application, then a site license may be required.

For radiating products, the Rosemount products are compliant with R&TTE Directive 1999/5/EC.

FCC license numbers for the Rosemount 5400 and 5600 Series:

- Rosemount 5401: K8C5401
- Rosemount 5402: K8C5402 (must be mounted in a tank)
- Rosemount 5600 Series, for applications in sealed metal tanks: K8CPRO (FCC rule part 15C), K8CPROX (FCC rule part 90)

The license numbers are included on the device labels.

In Canada, the following license numbers are valid for closed metal tanks:

- Rosemount 5401: 2827A-5401
- Rosemount 5402: 2827A-5402
- Rosemount 5600 Series: 2827A-5600PRO

No certificate is applicable for Non-intentional radiators.

The EC Declaration of Conformity for all applicable European directives for the Rosemount products can be found on the Rosemount website at www.rosemount.com. A hard copy may be obtained by contacting our local sales representative.

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Section 1 Power applications

1.1 Introduction

This document describes some of the best practices learned during the installation of thousands of Rosemount process radar level transmitters in power applications.

In a power plant, the radar applications can be divided into the following subcategories:

- Boiler systems
- Turbines
- Water supply and pre-treatment
- Cooling system
- Fuel supply
- Fuel combustion / clean-up
- Effluent
- Hydro power
- Miscellaneous

Each application differs in how the transmitters are to be installed to achieve optimized result. It is important to follow the best practice for the specific application. If unsure about the installation of your Rosemount radar transmitter, or you cannot find the suitable best practice for your application, contact your local Emerson Process Management representative for support.

For more information on how to choose the correct technology and transmitter for an application, see the Engineer's Guide to Level Measurement for Power and Steam Generation document, available to order on www.rosemount.com.

1.2 Boiler systems

For boiler systems, radar transmitters are commonly used for the following applications:

- Boiler drum level control
- High pressure feedwater heater
- Low pressure feedwater heater
- Steam separators (once through systems)
- Boiler blowdown tanks
- Flash / surge tanks
- Condenser hotwell
- Condensate storage
- Deaerator

1.3 Turbines

For turbines, radar transmitters are commonly used for the following applications:

- Gland steam condenser
- Lubrication oil tanks
- Hydraulic oil tanks

1.4 Water supply and pre-treatment

For water supply and pre-treatment activities, radar transmitters are commonly used for the following applications:

- Demineralization system / chemical storage
- Intake water screens
- Rock salt
- Brine tank
- Boric acid, heavy water and makeup water

1.5 Cooling system

For cooling systems, radar transmitters are commonly used for the following applications:

- Cooling tower basin
- Refrigerants

1.6 Fuel supply

For fuel supply, radar transmitters are commonly used for the following applications:

- Fuel oil storage
- Natural gas separators
- Coal crusher hopper
- Coal mill supply silo (bunker)
- Coal stack pile and other fuel sources (bark, garbage)

1.7 Fuel combustion / clean-up

For fuel combustion / clean-up, radar transmitters are commonly used for the following applications:

- Ammonia, anhydrous
- Ammonia, aqueous
- Ash slurry, lime slurry or liquid gypsum
- Sulfur solution tanks
- Scrubbers
- Ash hopper - bottom ash or fly ash
- Lime silo
- Powder Activated Carbon (PAC), combustion salt, bone meal, dried sludge

1.8 Effluent

For effluent, radar transmitters are commonly used for the following applications:

- Effluent flow
- Open atmosphere sumps
- Clarifiers

1.9 Hydro power

For hydro power, radar transmitters are commonly used for the following applications:

- Head and tail race
- Leaky weir at bottom of dam
- Water catchment (water supply level and silt detection)

1.10 Miscellaneous

For miscellaneous, radar transmitters are commonly used for the following applications:

- Sumps (drain pit for waste oil, condensate)
- Water wash tanks
- Fire water tanks
- Lake or pond level

Section 2 Installation considerations

2.1 Safety messages

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Please refer to the following safety messages before performing an operation preceded by this symbol.

⚠ WARNING

Explosions could result in death or serious injury.

Verify that the operating environment of the transmitter is consistent with the appropriate hazardous locations certifications.

Before connecting a HART®-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

Do not remove the gauge cover in explosive atmospheres when the circuit is alive.

Failure to follow safe installation and servicing guidelines could result in death or serious injury.

Make sure only qualified personnel perform the installation.

Use the equipment only as specified in this manual. Failure to do so may impair the protection provided by the equipment.

Do not perform any services other than those contained in this manual unless you are qualified.

Process leaks could result in death or serious injury.

Make sure that the transmitter is handled carefully. If the process seal is damaged, gas might escape from the tank if the transmitter head is removed from the probe.

High voltage that may be present on leads could cause electrical shock:

Probes covered with plastic and/or with plastic discs may generate an ignition-capable level of electrostatic charge under certain extreme conditions. Therefore, when the probe is used in a potentially explosive atmosphere, appropriate measures must be taken to prevent electrostatic discharge.

2.2 Introduction

In addition to selecting the appropriate radar level transmitter, mechanical installation is one of the most critical steps of the commissioning procedure. When done correctly, the subsequent transmitter configuration will be considerably simplified. Because of the wide usage and application in the power industry, this section provides a framework for chamber installations, tank installations, and solids measurements.

2.3 Chamber installations

Chambers - also known as bridles, side-pipes, bypass pipes, and cages - are typically used because:

- External mounting with valves allows for servicing of the level device, even in pressurized tanks that are in continuous operation for many years
- They allow for radar measurement in tanks or regions with side-connections only, such as boiler drum, condenser and feedwater tanks
- They provide a calmer surface in case of turbulence, boiling, or other conditions that upset the product

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NOTE:
For chamber installations, use metallic pipes exclusively.

However, chambers also have some disadvantages:

- Inlet pipes may clog and generate a discrepancy between the level inside the chamber and the actual level in the tank
- The effective measuring range is limited to the region between the upper and lower inlet pipes
- Different process conditions (temperature/pressure) in the chamber than in the tank may generate discrepancy between the level inside the chamber and the actual level in the tank

A pipe can increase the reliability and robustness of the level measurement, especially for non-contacting radar. It should be noted that the coaxial probe of a Guided Wave Radar (GWR) is essentially a probe within a small stilling well. It should be considered as an alternative to stilling wells for clean fluid applications.

Pipes completely isolate the transmitter from disturbances, such as other pipes, agitation, fluid flow, foam, and other objects. The pipes can be located anywhere in the vessel that allows access. For GWR, the microwave signals are guided by the probe, making it resistant to disturbing objects.

Bypass chambers may be located on a small portion of a tank or column and allow access to the measurement instrument.

Bypass chambers often include valves to allow instrumentation calibration verification or removal for service.

Bypass chambers and stilling wells are not without limitations. Generally, pipes should be used with cleaner fluids that are less likely to leave deposits and that are not viscous or adhesive.

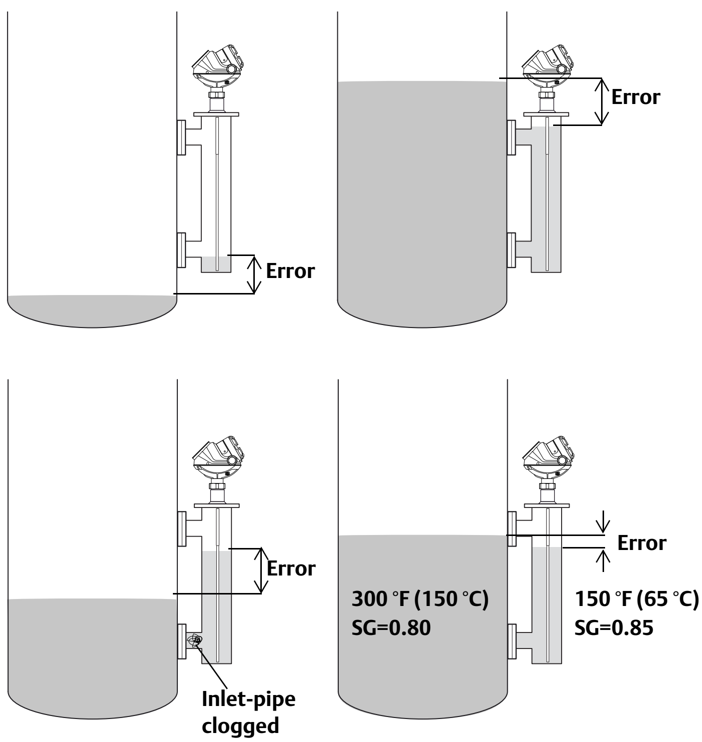
Apart from the additional cost of installation, there are some sizing and selection criteria for the radar gauges that must be considered. This document outlines those considerations.

GWR is the preferred technology for shorter installations where rigid probes may be used. This makes it a suitable replacement for caged displacers, which are often less than 10 ft. (3 m). The probes are available in a variety of materials to handle corrosive fluids.

For further information on how to replace displacers with GWR in existing chambers, see the Replacing Displacers with Guided Wave Radar Technical Note (Document No. 00840-2200-4811).

For taller applications or those with limited head space for installing rigid probes, non-contacting radar may be advantageous. Non-contacting radar is also the preferred technology for applications with heavy deposition or very sticky and viscous fluids.

Figure 2-1. Possible error sources in chamber installations



For application guidelines, see Section 1: Power applications.

2.3.1 High pressure steam applications

Phase changes

It is especially common during startup to experience varying temperature and pressure. Both the liquid and steam phases of the system will have density changes as the system reaches the operating temperature and pressure which can cause up to a 30% error over temperature up to 600 °F (315 °C), as seen in Table 2-1.

Any density-based level measurement device will need compensation to discern the actual level from the density-associated errors. Algorithms have been developed to make this compensation as seamless as possible in the control systems, but require input of operating pressure as well as level. Compensation can be slow which results in erroneous reading.

There will also be dielectric property changes both in the liquid and steam phases. Steam under high pressure will slow down the propagation speed of a radar signal which can cause over a 20% error over temperature if not compensated.

Even though the dielectric of water decreases with temperature increase, the level can be measured as long as the water dielectric remains sufficiently high, which results in a reflection back from the surface. However, as the temperature increases, the dielectric difference between the liquid and the steam becomes smaller, and at a certain point, it will be too small for reliable measurement with radar transmitters.

Between 2610 psi (180 bar) and 2900 psi (200 bar), the dielectric difference between steam and water becomes too small to offer reliable level measurement. In this case, GWR is no longer suitable.

Below 2610 psi (180 bar), GWR is a suitable means of measurement if compensation for the dielectric of the steam dielectric is completed.

Table 2-1. The error in distance with changing temperature and pressure, without vapor compensation[(1)].

Temp.°F/°C	Pressure psia/bar	DK of liquid	DK of vapor	Error in distance %
100/38	1/0.1	73.95	1.001	0.0
200/93	14/1	57.26	1.005	0.2
300/149	72/5	44.26	1.022	1.1
400/204	247/17	34.00	1.069	3.4
500/260	681/47	25.58	1.180	8.6
600/316	1543/106	18.04	1.461	20.9
618/325	1740/120	16.7	1.55	24.5
649/343	2176/150	14.34	1.8	34.2
676/358	2611/180	11.86	2.19	48
691/366	2900/200	9.92	2.67	63.4
699/370	3046/210	8.9	3.12	76.6
702/372	3120/215	Above critical point; distinct liquid and gas phases do not exist.		

Extreme high pressures and temperatures

In these applications, temperatures above 300 °F (150 °C) and pressures above 580 psi (40 bar) are common. Therefore, having robustly designed equipment which prevents leakage and performs reliably is vital for safety.

Magnetite coating

While these applications are generally considered to be composed of clean water and steam, it is normal to have a layer of magnetite on metallic surfaces. In some cases, the deposits can be heavy enough to cause some mechanical linkages to freeze and stick resulting in a need for maintenance. With no moving parts in the GWR probe assembly, magnetite poses no issues for sticking.

(1) Maximum limit for GWR is 180 bar. For applications over this pressure limit other solutions are used.

Heavy vibrations

Heavy vibrations from pumps can cause a noisy signal from mechanical-based techniques.

Advantages of GWR over other techniques

Since GWR measurement devices are completely independent of density, these associated errors are not present, thus eliminating the need for this compensation.

GWR has no moving parts that can freeze or stick from magnetite coating or cause noisy signal due to vibration. Therefore, GWR offers additional advantages of lower maintenance and greater stability.

Vapor compensation functionality

In the Rosemount 5300 Series Superior Performance GWR, there are two functions to compensate for the vapor dielectric:

- Static Vapor Compensation (SVC)
- Dynamic Vapor Compensation (DVC)

With either option, the compensation occurs in the transmitter electronics and a corrected level measurement is provided to the control system. No additional compensation is required.

As it can be seen in Table 2-1, at 247 psia (17 bar), there is an error in distance of 3.4%. At 1543 psia (106 bar), there is an error of 20.9% when there is no compensation for the vapor dielectric.

The error in distance increases with the pressure, and at some point this deviation is not negligible and must be taken into account in order to get high accuracy.

Static vapor compensation (SVC)

For the static compensation function, the dielectric of the vapor at expected operating pressure and temperature is manually entered as part of the configuration of the transmitter. This allows the unit to compensate for the dielectric at operating conditions.

The static compensation works well under stable conditions and in these applications, the standard High Temperature/High Pressure (HTHP) probe is used.

Dynamic vapor compensation (DVC)

DVC becomes more important for the higher pressure applications which may have more variations in the operating conditions or where the users want to be able to verify the unit under near ambient conditions, such as during startup and shutdown, without having to modify the vapor dielectric settings.

Vapor dielectric does not affect the measurement accuracy until the pressure is higher than 145 psia (10 bar). DVC should be considered when the pressure is above 247 psia (17 bar) when the error is more than 2%, see Table 2-3 on page 13. In these cases, DVC can bring the error back to 2%, or in some conditions even down to 1%.

Application and installation conditions, such as lower temperature in the bypass chamber, can cause changes within the measured media. Therefore, the error readings can vary depending on the application conditions and may cause an increase of the measuring error by a factor of 2 to 3.

DVC requires a special probe with a built-in reflector for measurement of the dielectric of the steam.

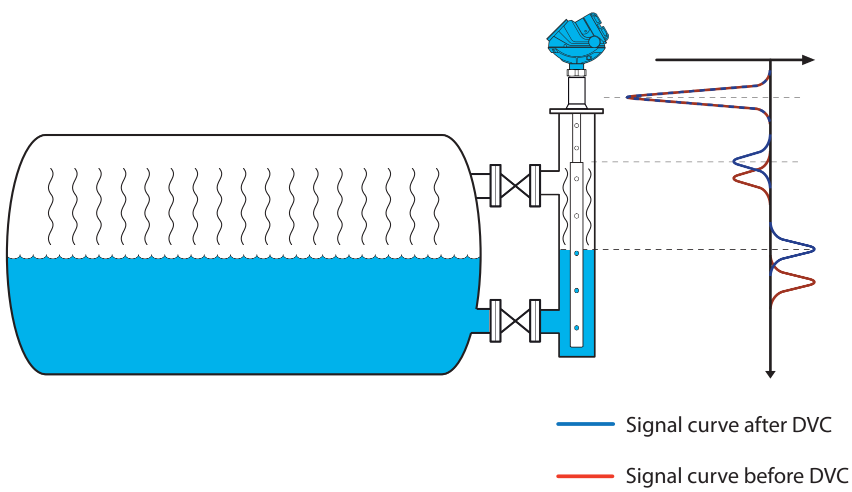
DVC works by using a target at a fixed distance. With this target, the vapor dielectric is measured continuously.

The transmitter knows where the reflector pulse should have been if there were no vapor present. However, since there is vapor in the tank, the reflector pulse appears beyond the actual reflector point.

The distance between the actual reflector point and the apparent reflector point is used to calculate the vapor dielectric. The calculated dielectric is then dynamically used to compensate for vapor dielectric changes and eliminates the need to do any compensation in the control system.

When the distance between the mounting flange and the surface is less than 22 in. (560 mm) for the short reflector, and 28 in. (710 mm) for the long reflector, the function switches from dynamic to static vapor compensation using the last known vapor dielectric constant.

Figure 2-2. Radar signal curve before and after vapor compensation(1)



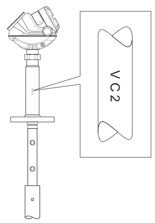
(1) *The figure illustrates the radar signal curve before and after vapor compensation. Without compensation, the surface pulse appears to be beyond the actual level. After compensation, the surface appears at the correct surface level point.*

Rosemount design advantages

Rosemount 5300 GWR extreme temperature and pressure probes are designed to prevent leakage and perform reliably when exposed to extreme process conditions for extended periods of time. Materials are selected to avoid stress fractures commonly induced by changes in temperature and pressure conditions.

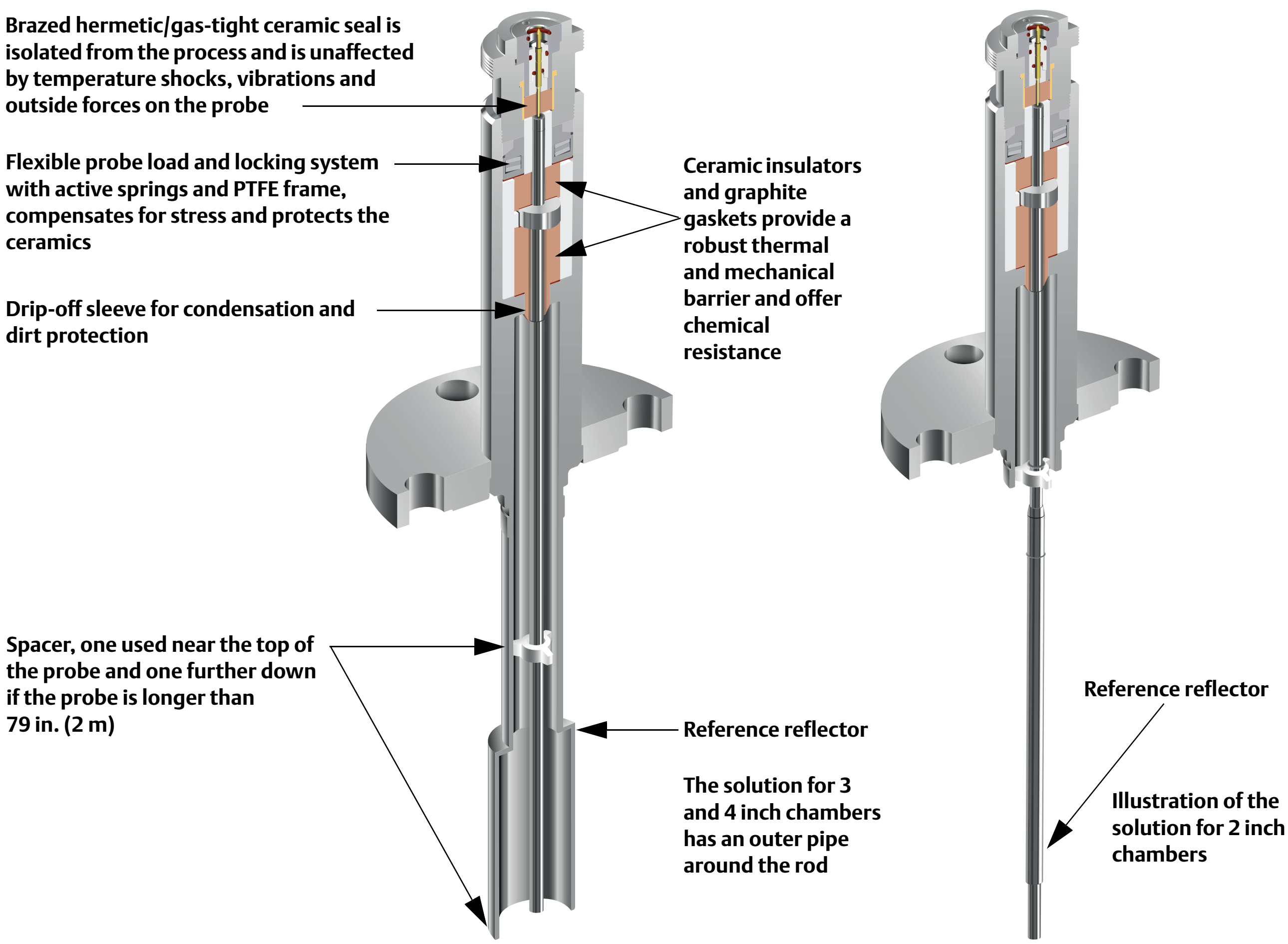
The robustness of the probes and materials means high safety for these extreme temperature and pressure applications.

Figure 2-3. Probe with reference reflector marked "VC2" for recognition



The GWR probe design provides multiple layers of protection

Figure 2-4. HTHP seal



DVC installation best practices

The GWR should be mounted in a bypass chamber with flanges appropriately sized for the pressure and temperature of the application. A 3 or 4 inch (75 or 100 mm) diameter chamber is recommended as best practice, but the GWR can also be mounted in a 2 inch (50 mm) chamber.

Materials used for the chamber should meet local boiler code requirements and the chamber should be isolated directly from the boiler or high pressure heater by valves.

A specially designed HTHP probe with reference reflector for vapor compensation should be used. For 2 in. (50 mm) chambers, this probe is a single rigid probe, and for 3 and 4 in. (50 and 100 mm) chambers this is a single rigid probe with an outer pipe.

Probes up to 13.1 ft. (4 m) length are supported for DVC.

DVC requires a minimum distance from the flange to the surface level to measure the change in the vapor dielectric constant. If the level rises within this area, the unit switches over to static compensation, using the last known vapor dielectric constant.

This minimum distance (indicated by X in Figure 2-9 on page 18) is 22 in. (560 mm) for the short reflector, and 28 in. (710 mm) for the long reflector, to dynamically compensate up to 100%.

The minimum measuring range for this functionality is 12 in. (300 mm).

Table 2-2. Minimum distance X

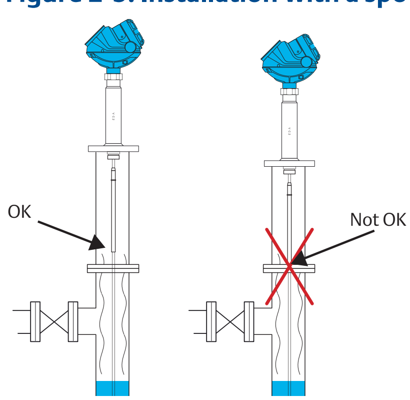
Probe length	Reflector	Minimum distance X
35 - 158 in. (900 - 4000 mm)	14 in. (350 mm)	22 in. (560 mm)
43 - 158 in. (1100 - 4000 mm)	20 in. (500 mm)	28 in. (710 mm)

If a 5300 Series GWR transmitter is ordered from Rosemount together with a 9901 Chamber, these space requirements are met by using the option code G1 or G2 for the chamber. G1 is used with the short reflector, and G2 is used with the long reflector.

If an existing chamber is used which does not meet these space requirements, a spool piece can be added. For an installation with a spool piece with the 2 in. DVC solution, it is important to make sure that the reference reflector and the spool piece do not have the same length.

The spool piece needs to be at least 2 in. (50 mm) longer or shorter. For a spool piece with the 3 and 4 in. DVC solution, this is not a requirement.

Figure 2-5. Installation with a spool piece



NOTE:
If a spool piece is used with the single lead probe designed for 2 in. chambers, it is important that the reference reflector and the spool piece do not have the same length.

For high pressure steam applications above 400 psi (28 bar), it is also important to limit the overall distance from the flange to where the level is controlled (indicated by A in Figure 2-6), since the high pressure affects the dielectric properties of the vapor causing an error in distance measured, see Table 2-1 on page 8[1]. The overall error increases with the pressure and is a percentage of distance measured. Even if DVC is used and corrects the error of 8.6% at 681 psi (47 bar) to 2 %, the 2% error may be larger than desired.

Figure 2-6. Limiting the overall distance A helps to minimize accuracy errors caused by the vapor

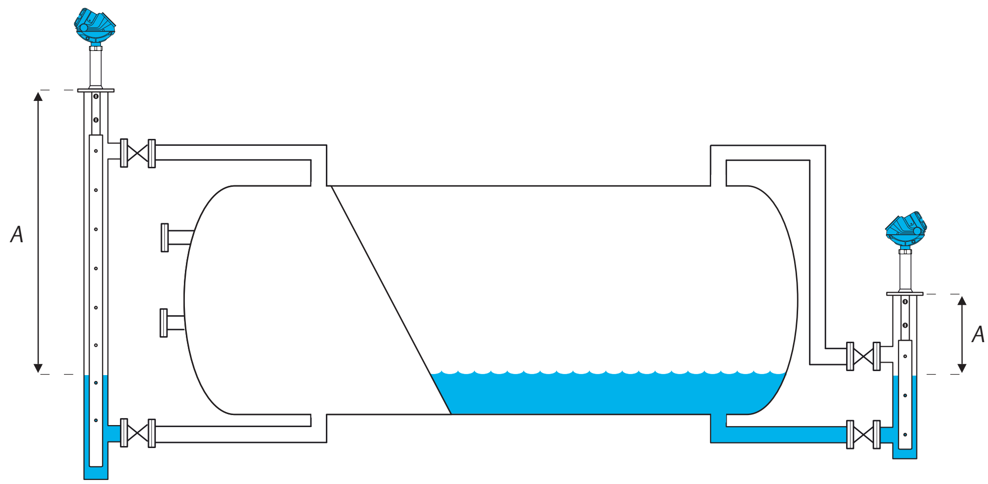


Table 2-3. The error in distance with and without DVC at a pressure of 600 psi (41 bar)

Distance A	Error with no correction	Error corrected to 2% with DVC
100 in. (2540 mm)	- 7.6 in. (- 193 mm)	- 2 in. (- 50.8 mm)
50 in. (1270 mm)	- 3.8 in. (- 96.5 mm)	- 1 in. (- 25.4 mm)

NOTE:
DVC has a minimum distance requirement from the flange to the upper inlet to dynamically compensate up to level 100%. See Figure 2-9 on page 18 for details.

For example, if a GWR is installed in a chamber that covers the full height of a 10 ft (3 m) tank, the distance to the surface level may be as much as 9 ft (2.75 m). A 2% error over 9 ft (2.75 m) is 2.16 in. (54.9 mm). If a shorter system is used, such as the minimum size needed to replace the 14 in. (355.6 mm) displacer (approximately 35 in. (889 mm) total), then the overall distance to the surface would be about 24 in. (609.6 mm). With this distance, the 2% error shrinks to ± 0.48 in. (12.3 mm).

For further guidelines for choosing and installing radar in chambers or stilling wells, see the Guidelines for Choosing and Installing Radar in Stilling Wells and Bypass Pipes (Document No. 00840-0300-4024), and Replacing Displacers with Guided Wave Radar (Document No. 00840-2200-4811) Technical Notes.

(1) See the Using Guided Wave Radar for Level in High Pressure Steam Applications Technical Note (Document No. 00840-0100-4530) for details.

How to choose reflector length

The long reflector, 20 in. (500 mm), has the best accuracy and is recommended for all chambers where the dimensions of the chamber allow for it.

If the distance from the flange to the upper inlet is less than 28 in. (710 mm), the short reflector should be chosen.

This distance is a minimum when dynamic compensation is required within the whole measuring range from the lower to the upper inlet. If this is not required, the long reflector can be used and dynamic compensation is possible up to 28 in. (710 mm) from the flange.

However, always ensure that there are no disturbances from inlets etc close to the reference reflector end when using the 2 in. DVC solution.

DVC calibration

When a transmitter is ordered with the optional DVC, the function is activated from factory and the special probe is supplied. For the 2 in. solution, a calibration procedure is needed on-site during the commissioning phase. For the 3 and 4 in. solution, the transmitter is calibrated from factory and no calibration on-site is normally needed. There are, however, two cases where a calibration procedure is needed for the 3 and 4 in. solution; if the transmitter is reset to factory settings which will delete the DVC calibration, or if a different transmitter head is mounted on the DVC probe.

If a calibration procedure is needed, this should be performed with an empty chamber at ambient conditions.

For best performance, it is recommended that the chamber is cleared of any steam and/or condensate prior to the calibration. See the Reference Manual supplied with the transmitter for details on the calibration procedure.

Note that Probe End Projection and Signal Quality Metrics are disabled when DVC is enabled. To minimize errors due to installation, it is recommended that:

- the distance between the chamber and the vessel be kept as short as possible
- connections to the chambers should be large enough to allow good fluid flow through
- the chamber and the piping to it should be well insulated so the fluid temperature is as close as possible to the vessel temperature

For further information on chamber insulation, see "Insulation" on page 22.

2.3.2 Chamber fabrication and probe selection

Dimensioning the chamber correctly and selecting the appropriate probe is key to success in guided wave radar applications. Either follow the recommendations below and have the chamber manufactured accordingly, or purchase the Rosemount 3300 or 5300 Series transmitter bundled with the Rosemount 9901 Chamber where Emerson has already incorporated these best practices. See the Rosemount 9901 Chamber for Process Level Instrumentation Product Data Sheet (Document No. 00813-0100-4601) for a 9901 model code example.

The recommended chamber diameter is 3 in. (75 mm) or 4 in. (100 mm). Chambers with a diameter less than 3 in. (75 mm) may cause problems with build-up and it may also be difficult to center the probe. Chambers larger than 6 in. (150 mm) can be used, but provide no advantages for the radar measurement[1].

When specifying a chamber, it is also important to consider the physical weight of the instrument and chamber, the properties of the liquid, and the chance of plugging due to the build-up of deposits.

The location of the side-pipes and the effective measurement range is determined by the mating tank connections. There are no diameter requirements for the side-pipes, but build-up and clogging should be taken into consideration.

The recommended inlet pipe diameter is not less than 1 in. (25 mm) for water (filtered minimal quality), lube oil, or liquids with similar viscosity. For fuel oil, bunker oil, that is liquids with higher viscosity, the minimum recommended inlet pipe diameter is 2 in. (50 mm).

Note that the diameter of the inlet pipe should always be less than the chamber diameter. Ensure that the inlet pipes do not protrude into the chamber because they may interfere with the radar measurement. Always use the same material of construction for the chamber and the tank or mechanical tensions can arise in the side-connections.

In hot applications, it is recommended to keep the length of the inlet pipes as short as possible to minimize temperature drop between tank and chamber.

To simplify the verification process of the Rosemount GWR transmitters, venting is recommended to manipulate the level in the cage and to drain the cage. A standard integral cage vent located on the top part of the chamber (typical position is right below the flange), and a drain at the bottom of the chamber, are suitable. Refer to the Rosemount 9901 Series Product Data Sheet (Document No. 00813-0100-4601) for information. The vent and drain make it possible to isolate the whole chamber during fill/drain procedures.

For the Rosemount 5300 Series with DVC special considerations to chamber dimensioning apply. A 3 or 4-in. (75 or 100 mm)[2] inner diameter bypass chamber with flanges appropriately sized for the pressure and temperature of the application is required. Materials used for the chamber should meet ASME boiler code requirement and the chamber should be isolated from the boiler or HP heater by valves.

With the Rosemount GWR transmitters it is recommended that single probes in chambers be used[3]. The single lead probe can tolerate any magnetite layer that may occur. The probe must not touch the chamber wall and should extend the full height of the chamber, but should not touch the bottom of the chamber. Allow for transition zones (varies with probe type and dielectric of the media), see Table 2-5 on page 17. Also consider type of flushing connection to simplify calibration verification, and cleaning.

Probe type selection depends on the probe length:

Probe length is less than 3 ft (1 m): Use a single rigid probe and no centering disk is needed[4].

(1) The single probe creates a virtual coaxial probe with the chamber as the outer tube which helps to amplify the signal returned from the media.
(2) It is possible to use a chamber with a 2 in. (50 mm) inner diameter, but not recommended as best practice.
(3) The single probe creates a virtual coaxial probe with the chamber as the outer tube. The extra gain provided by the twin and coaxial probes is not necessary; the electronics in the Rosemount 5300 Series is very sensitive and is not a limiting factor.
(4) The transition zones, and the height of the weight, limit the usage of single flexible probes shorter than 3 ft (1 m).

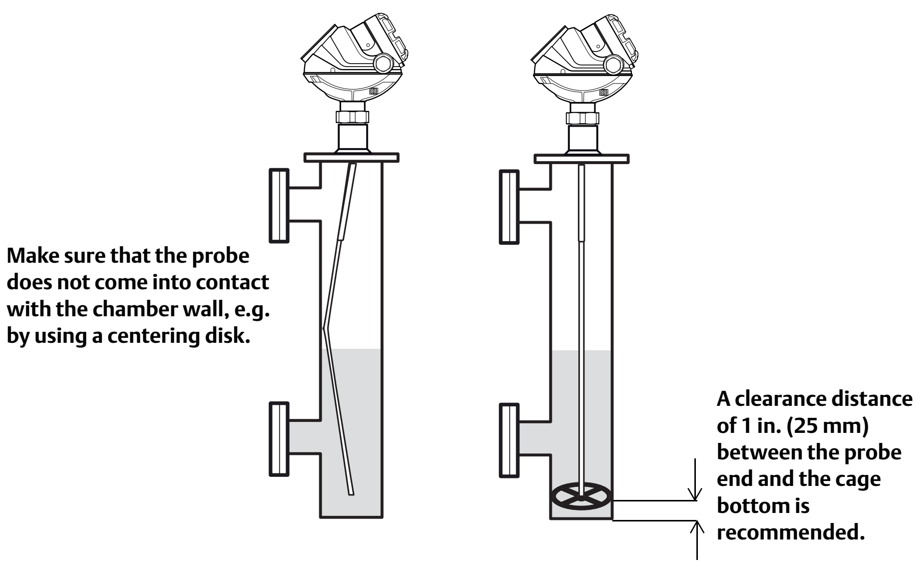
Probe length is between 3 ft (1 m) and 10 ft (3 m)[(1)]: Use either a rigid single or a flexible single probe with weight and a centering disk. The rigid single is easier to clean and has smaller transition zones, while the flexible single requires less head-space during installation and is less likely to be damaged.

Probe length is more than 10 ft (3 m)[(1)]: Use a flexible single probe with weight and a centering disk. Minimum chamber diameter is 3 in. (75 mm).

For very narrow chambers with a diameter less than 2 in. (50 mm), a coaxial probe can be used to help reduce the impact of possible disturbances, such as splashing from upper inlet pipes. However, since the coaxial probe is more sensitive to build-up, it is only recommended for very clean liquids. For a chamber with a diameter equal to or larger than 3 in. (75 mm), the single lead probe is therefore the preferred choice.

NOTE:
For the coaxial probe, the minimum chamber diameter is 1.5 in. (837.5 mm).

Figure 2-7. Improper and proper probe positions



To avoid bending the probe (rigid probes), or twisting (flexible probes), and coming into contact with the chamber wall a small clearance distance between the centering disk and the chamber bottom is recommended. A clearance distance of 1 in. (25 mm) is suggested assuming a dome shaped chamber bottom, which may prevent the centering disk from reaching the bottom.

Transition zones, located at the very top and bottom of the probes, are regions where measurement performance is reduced. Different factors affect the size of the transition zones - probe type, centering disk or no centering disk, and the material and media measured (see Table 2-5). The weight on the flexible probes reduces the measurement range. Therefore, it is recommended to size the cage (A, C) so it does not interfere with the effective measurement range (B). The transition zones also limit the minimum probe length.

(1) For a Rosemount 5300 Series with DVC, only rigid probes are available in lengths up to 13 ft (4 m).

Table 2-4. Transition zones for the Rosemount 3300 Series installed in metallic pipes

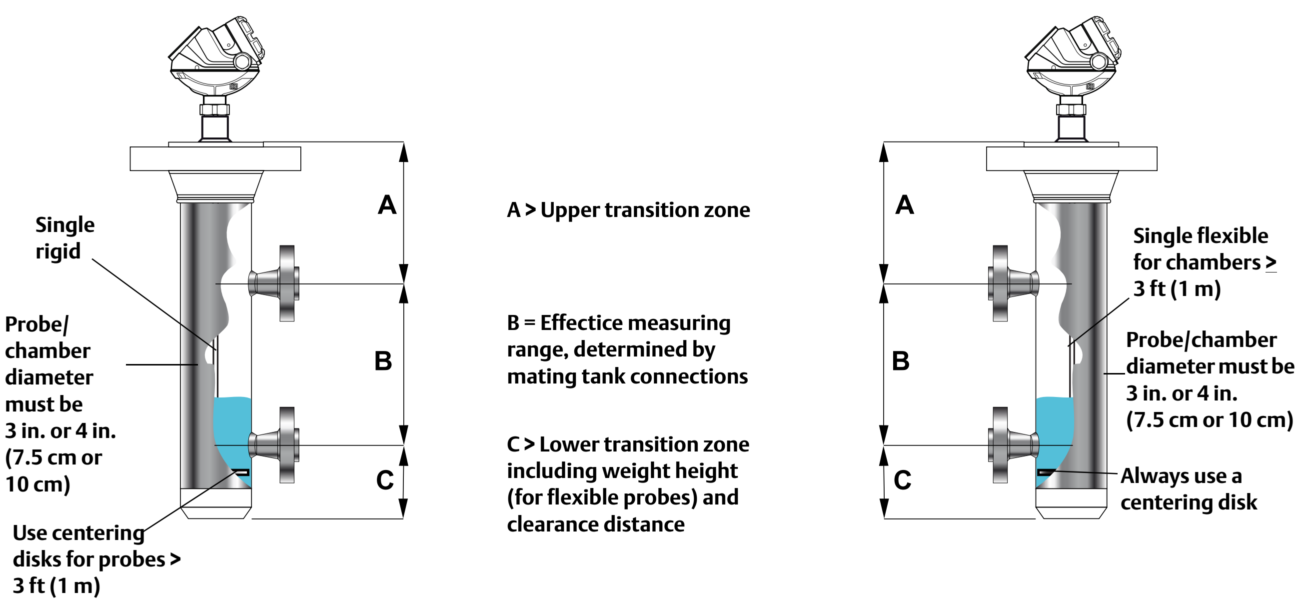
Probe Size	Upper Transition Zone		Lower Transition Zone	
	High Dielectric	Low Dielectric	High Dielectric	Low Dielectric
Single Rigid	4 in. (10 cm)	4 in. (10 cm)	2 in. (5 cm)	4 in. (10 cm)
Single Flexible	5.9 in. (15 cm)	8 in. (20 cm)	7.5 in. (19 cm)	10.2 in. (26 cm)
Coaxial	4 in. (10 cm)	4 in. (10 cm)	1.2 in. (3 cm)	2 in. (5 cm)

Table 2-5. Transition zones in chambers for the Rosemount 5300 Series installed in metallic pipes

	Dielectric Constant	Rigid Single Lead(1),(2)	Rigid Single Lead, with metallic centering disk	Flexible Single Lead(1)	Coaxial(3)
Upper(4) Transition Zone	80 (water)	4.3 in. (11 cm)	4.3 in. (11 cm)	4.3 in. (11 cm)	4.3 in. (11 cm)
	2 (oil)	6.3 in. (16 cm)	6.3 in. (16 cm)	7.1 in. (18 cm)	4.3 in. (11 cm)
Lower(5) Transition Zone	80 (water)	2 in. (5 cm)	2 in. (5 cm)	5.5 in. (14 cm)	4 in. (10 cm)
	2 (oil)	2.8 in. (7 cm)	8 in. (20 cm)	7.5 in. (19 cm)	5.5 in. (14 cm)

(1) Single probes are the preferred choice.
(2) Rigid Single Lead probe without SST centering disk or with a PTFE centering disk.
(3) Coaxial should only be used for very clean or low DC applications.
(4) The distance from the upper reference point where measurements have reduced accuracy, see A in Figure 2-8.
(5) The distance from the lower reference point where measurements have reduced accuracy, see C in Figure 2-8.

Figure 2-8. Measuring zones in chambers



An example using the guidelines for fabrication of cages (see Table 2-5 on page 17 for transition zones).

Assuming level measurement of oil (worst-case): A > 6.3 in. (16 cm) and C > 9.8 in. (25 cm) for a rigid single probe with a metallic centering disk, and A > 7.1 in. (18 cm) and C > 9.4 in. (24 cm) for a single flexible probe with a standard weight. There is a 2 in. (5 cm) clearance between the cage bottom and the end of the probe included in the C-dimensions.

For the Rosemount 5300 Series with DVC a minimum distance from the flange to the surface level is required to measure the change in the vapor dielectric constant. This minimum distance (X in Figure 2-9) is 22 in. (560 mm) for the short reflector, and 28 in. (710 mm) for the long reflector, to dynamically compensate up to level 100%. The minimum measuring range for this functionality is 12 in. (300 mm). If a Rosemount 5300 Series transmitter is ordered from Rosemount together with a 9901 Chamber, these space requirements are met.

When the distance between the mounting flange and the surface is less than X (see Figure 2-9), the function switches from dynamic to static vapor compensation using the last known vapor dielectric constant.

NOTE:
The distance requirements (X in Figure 2-9) stated above only apply if dynamic compensation is required within the whole measuring range from lower to upper inlet. However, always ensure that there are no disturbances from inlets etc. close to the reference reflector end.

Figure 2-9. DVC minimum distance

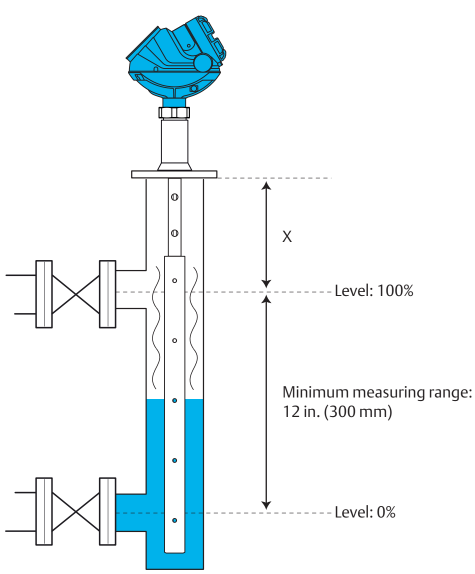


Table 2-6. Minimum distance X

Probe Length	Reflector	Minimum Distance X
35 - 158 in. (900 - 4000 mm)	14 in. (350 mm)	22 in. (560 mm)
43 - 158 in. (1100 - 4000 mm)	20 in. (500 mm)	28 in. (710 mm)

2.3.3 Chamber mounting

Chambers should be mounted onto the tank to correspond with the desired measurement and area of control. This is often a small portion of the overall height. For further information on chamber mounting in the control area, see "DVC installation best practices" on page 12.

2.3.4 Existing chambers

Retrofitting of existing chambers is very common, especially when replacing old mechanical devices such as displacers. For further information, see the Replacing Displacers with Guided Wave Radar Technical Note (Document No. 00840-2200-4811).

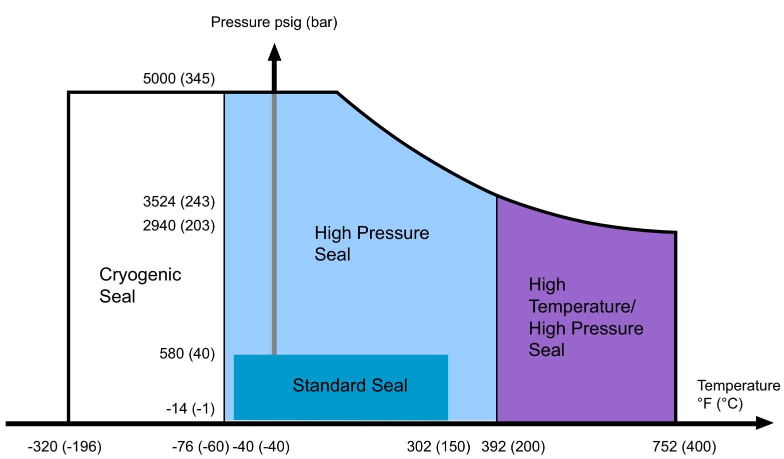
If an existing chamber is used, a spool piece might need to be added. For further information on installation with a spool piece, see "DVC installation best practices" on page 12.

2.3.5 Pressure and temperature specifications

The following diagram gives the process temperature (maximum product temperature at the lower part of the flange) and pressure ratings for chamber/ tank connections of the Rosemount 3300 and 5300 Series.

NOTE:
The process seal pressure and temperature specifications must comply with the design temperature and the design pressure for the application. In a chamber installation, there may be temperature differences between the chamber and the tank.

Figure 2-10. Recommended choice of process seal type

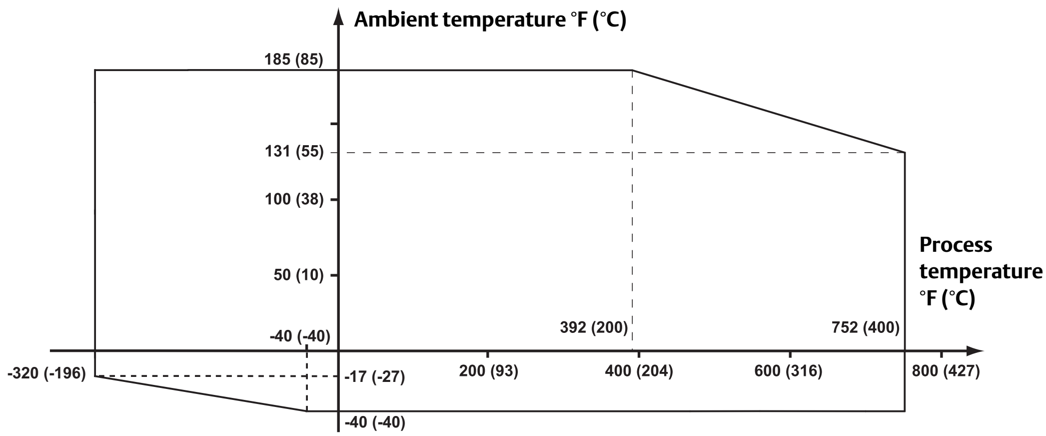


For additional information on pressure and temperature specifications, refer to *White paper: Selecting the correct process seal for Rosemount GWR products Rev 1. September 2009*.

When installing a Rosemount GWR transmitter in high temperature applications, it is important to consider the ambient temperature. The Rosemount 5300 Series transmitter electronics have requirements for maximum ambient temperature of 140 °F (60 °C), 158 °F (70 °C), or 176 °F (80 °C) (limits depend on Ex approval, and Hart vs. FF protocol), refer to the product-related

Product Data Sheet for more information. The ambient temperature is affected by the process temperature. Figure 2-11 shows the ambient temperature vs. process temperature.

Figure 2-11. Ambient temperature vs. process temperature



NOTE:
The final maximum ambient temperature rating depends on the type of approval.

In high temperature applications, the ambient temperature limit of the electronics may be exceeded when mounted close to the vessel. To prevent this, the remote connection described in the next section should be considered.

2.3.6 Remote housing

A remote housing connection can be used with Rosemount 5300 Series Superior Performance GWR transmitters to enable reliable measurement in environments where very high ambient temperatures or excessive vibrations exist at the mounting location of the vessel. It enables the transmitter electronics to be mounted away from the probe, such as to lower the ambient temperature, or to place the housing in a better location, for example to be able to read the display, or enable installation in tight spaces.

The remote housing connection is specified to handle 302 °F (150 °C). The cable used is an SST flexible armored coaxial cable which is delivered with a mounting bracket for wall or pipe mounting.

The remote housing connection is available in lengths of 3.2 ft (1 m), 6.5 ft (2 m), or 9.8 ft (3 m).

Figure 2-12. Rosemount 5300 Series with remote housing

When the remote housing is used together with the Rosemount 5300 Series, there may be a limit on measuring range and a decrease in accuracy. This is because the remote housing introduces a double bounce in the tank signal at 1.5 times the remote housing cable length. Because the double bounce occurs at approximately 1.5 times the remote housing cable length, a longer remote housing cable can increase the maximum measuring range for distances up to 10 ft (3 m). Table 2-7 shows the maximum recommended measuring range with remote housing for different remote housing lengths, installation types, dielectric constants, and probe types.

Table 2-7. Rosemount 5300 Series remote housing measuring range

		Dielectric Constant	Rigid Single 8 mm	Rigid Single 13 mm	Flexible Single
1 m Remote Housing	Chamber / pipe installations ≤ 4 in. (100 mm)	2 80	10 ft (3 m)[1] 10 ft (3 m)	15 ft (4.5 m)[1] 15 ft (4.5 m)[1]	33 ft (10 m)[1] [2] 33 ft (10 m)[1] [2]
	Tank installations	2 80	4 ft (1.25 m) 10 ft (3 m)[1]	4 ft (1.25 m) 10 ft (3 m)[1]	4 ft (1.25 m) 159 ft (48.5 m)[1]
2 m Remote Housing	Chamber / pipe installations ≤ 4 in. (100 mm)	2 80	10 ft (3 m)[1] 10 ft (3 m)	15 ft (4.5 m)[1] 15 ft (4.5 m)	33 ft (10 m)[1] [2] 33 ft (10 m)[1] [2]
	Tank installations	2 80	9 ft (2.75 m) 10 ft (3 m)[1]	9 ft (2.75 m) 10 ft (3 m)[1]	9 ft (2.75 m) 154 ft (47 m)[1]
3 m Remote Housing	Chamber / pipe installations ≤ 4 in. (100 mm)	2 80	10 ft (3 m)	15 ft (4.5 m) 15 ft (4.5 m)	33 ft (10 m)[1] [2] 33 ft (10 m)[1] [2]
	Tank installations	2 80		14 ft (4.25 m) 15 ft (4.5 m)[1]	14 ft (4.25 m) 149 ft (45.5 m)[1]

(1) Accuracy may be affected up to ± 1.2 in. (30 mm).
(2) Required chamber/pipe size is 3 or 4 in. (75 -100 mm).

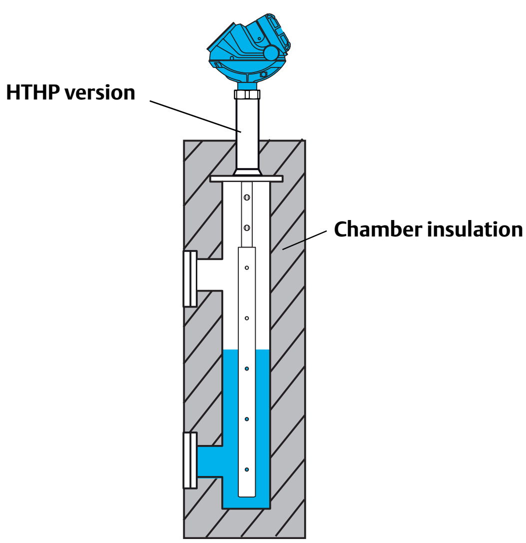
2.3.7 Insulation

The chamber should always be insulated in hot applications to prevent personal injuries and reduce the amount of energy needed for heating. It is often an advantage, and sometimes even required, for the radar measurement:

- In hot applications, insulation will reduce the amount of condensation, since it prevents the upper part of the chamber from becoming a cold spot
- In hot applications, insulation will reduce the temperature drop between the tank and chamber. This is important since lower temperature fluids have higher density and less volume. There is a risk that the level height could be less in the chamber since the volume of higher density fluid will be smaller. See "Installation and location errors" on page 73 for details. Heat tracing, well insulated inlet pipes, and a good flow-through will also help to reduce the temperature change.
- Insulation prevents the product from solidifying inside the chamber, and clogging the inlet-pipes

When the Rosemount 5300 Series is installed in high or low temperature applications, it is important that the maximum/minimum ambient temperature is considered. Nozzle/chamber/tank insulation for the HTHP process seal version should not exceed 4 in. (10 cm) at the flange.

Figure 2-13. Chamber insulation



2.4 Tank installations

2.4.1 Recommended mounting position

When finding an appropriate mounting position for the transmitter, the conditions of the tank must be carefully considered.

For the Rosemount GWR transmitters:

- Do not mount close to inlet pipes and ensure that the probe does not come in contact with the nozzle (X)
- If there is a chance that the probe may come in contact with the tank wall, nozzle, or other tank obstructions, the coaxial probe is the only recommended choice. However, it should only be used with clean liquids. Recommended clearance is given in Table 2-8 below
- If the probe sways due to turbulent conditions, the probe should be anchored to the tank bottom (Y). Refer to the Rosemount 3300 or 5300 Series Reference Manual (Document No. 00809-0100-4811 or 00809-0100-4530) for anchoring options. Also note that violent fluid movements that cause high sideway forces may break rigid probes.

Figure 2-14. Mounting considerations

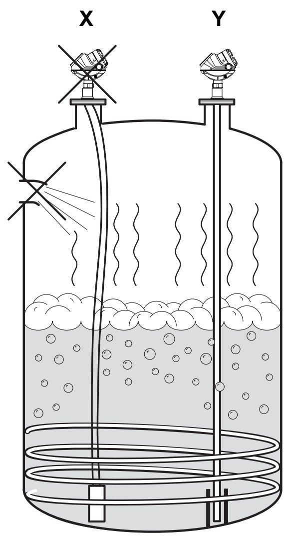


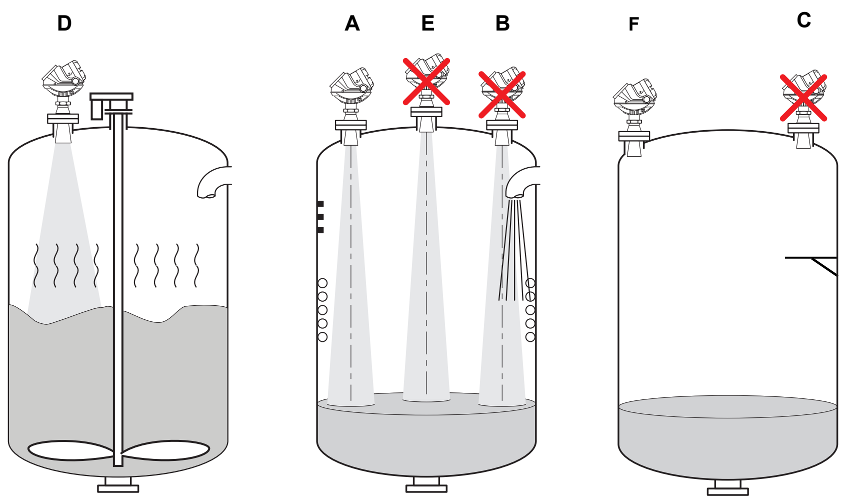
Table 2-8. Recommended clearance for probes

	Coaxial	Rigid Single Lead	Flexible Single Lead
Min. clearance to tank wall or obstruction	0 in. (0 cm)	4 in. (10 cm) in the case of smooth metallic walls. 20 in. (50 cm) in the case of disturbing objects, rugged metallic or concrete/plastic walls.	4 in. (10 cm) in the case of smooth metallic walls. 20 in. (50 cm) in the case of disturbing objects, rugged metallic or concrete/plastic walls.

The Rosemount 5400 Series non-contacting radar transmitters should be installed in locations with a clear and unobstructed view of the level surface (A) for optimum performance:

- Filling inlets creating turbulence (B), and stationary metallic objects with horizontal surfaces (C) should be kept at a distance, outside the signal beam. Refer to the Rosemount 5400 Series Product Data Sheet for more information (Document No. 00813-0100-4026)
- Agitators with large horizontal blades may reduce the performance of the transmitter, so install the transmitter in a location where this effect is minimized. Vertical or slanted blades are often invisible to radar, but create turbulence (D)
- Do not install the transmitter in the center of the tank (E)
- Because of circular polarization (only Rosemount 5400 Series), there is no clearance distance requirement from the tank wall if it is flat and free from obstructions, such as heating coils and ladders (F). Usually, the optimal location is 1/3 of the radius from the tank wall

Figure 2-15. Proper and improper locations for the Rosemount 5400 Series transmitter



2.4.2 Nozzle considerations

Depending on the selection of transmitter model and probe/antenna, special considerations may have to be taken because of the nozzle.

Rosemount GWR transmitters

The coaxial probe signal is unaffected by the nozzle. The single probe has some nozzle restrictions, e.g. avoid using nozzles with reducers, and nozzles that are too tall or too narrow.

Figure 2-16. Rosemount 5300 Series mounting in nozzles

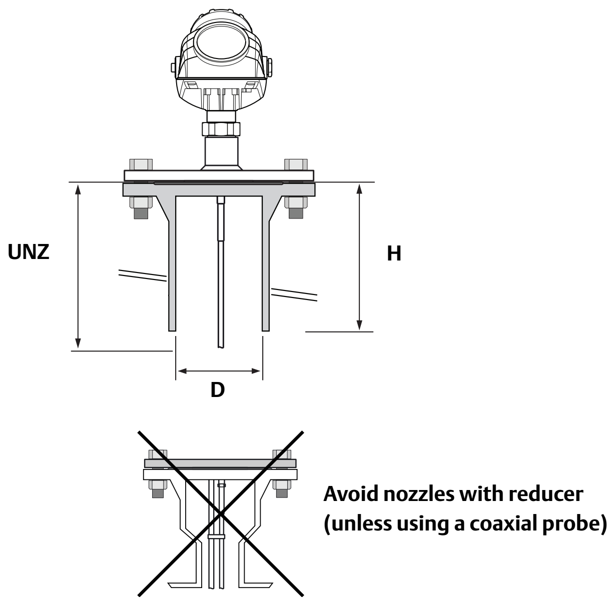


Table 2-9. Rosemount 3300 and 5300 Series nozzle considerations

	Single (Rigid/Flexible)	Coaxial
Recommended Nozzle Diameter (D)	3 - 4 in. (75 - 100 mm)	> probe diameter
Minimum Nozzle Diameter (D)(1)	2 in. (50 mm)	> probe diameter
Recommended Nozzle Height (H)(2)	4 in. + nozzle diameter(3)	N/A

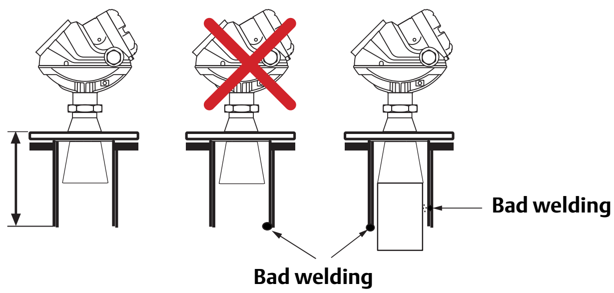
(1) The Trim Near Zone function may be necessary or an Upper Null Zone setup may be required to mask the nozzle.
(2) Longer nozzles may be used in certain applications. Consult your local Emerson Process Management representative for details.
(3) When using single flexible probes in tall nozzles, it is recommended to use the Long Stud (LS).

Rosemount 5400 Series non-contacting radar transmitter

- Rosemount 5402 with cone antenna

The antenna can be used in nozzles equal to or larger than 2.2 in (55 mm). It can be recessed in smooth nozzles up to 6 ft (2 m). However, if the inside of the nozzle contains disturbing objects, use the extended cone, see Figure 2-17. Make sure the antenna is never the same height as the nozzle. Because Rosemount 5402 has a high frequency (26 GHz), this generates a narrower beam width, which can allow for the antenna to recess up in the nozzle. Although, for best performance, it is recommended that the antenna extend 0.4 in. (10 mm) or more below the nozzle. Refer to the Rosemount 5400 Series Reference Manual (Document No. 00809-0100-4026) for details.

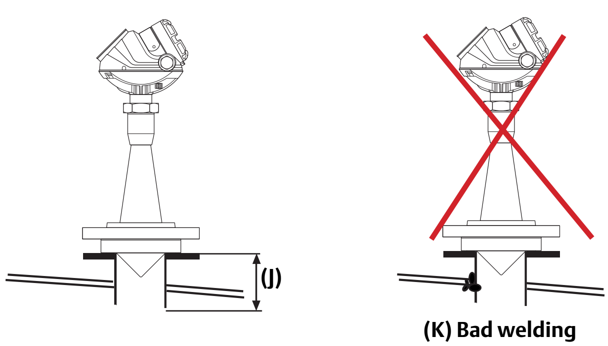
Figure 2-17. Rosemount 5402 with cone antenna



- Rosemount 5402 with process seal antenna

The antenna can be used in 2, 3, and 4 in. (50, 75, and 100 mm) nozzles up to 6 ft (2 m) tall (J), but disturbing objects inside the nozzle (K) may impact the measurement, and should be avoided. For best performance, the recommended maximum nozzle height is 19.7 in. (500 mm). The flange on the tank should have a flat or raised face, but other tank flanges may be possible. Consult your local Emerson Process Management representative for assistance.

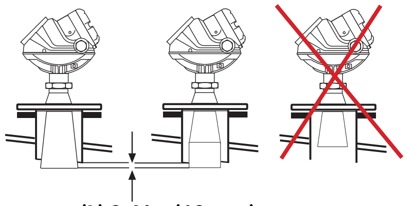
Figure 2-18. Rosemount 5402 with process seal antenna



- Rosemount 5401 with cone antenna

This antenna can be used in tanks with nozzles equal to or larger than 4 in. (100 mm) and should extend 0.4 in. (10 mm) or more below the nozzle (L). If required, use the extended cone solution. The Rosemount 5401 is low frequency (6 GHz), the Rosemount 5402 is high frequency (26 GHZ), which generates a wider beam width, and thus it should not be recessed up in the nozzle as this will disrupt the radar beam.

Figure 2-19. Rosemount 5401 with cone antenna



If the signal is dampened by heavy condensation at the antenna, it often helps to insulate the nozzle. This is to minimize the temperature disparity between the internal and the ambient temperature.

2.4.3 Probe and antenna selection

In addition to the mounting position, nozzle considerations, and process insulation, there are other factors that need to be taken into consideration when selecting the probe or antenna.

Probe selection

- Single probes are recommended in most applications. The coaxial probes have longer measuring ranges than the single probes, but are more sensitive to build-up and coating.
- Always ensure that the wetted materials are compatible with the process and that the probe will withstand the application's temperature and pressure range.
- In case of corrosive tank media, consider using a probe in exotic materials (Alloy C-275 or 400) with protective plate design(1) or, alternatively, PTFE-coated probes(2). PTFE-coated probes can also be used for applications with build-up or condensation.
- Build-up on probes can be monitored by the Signal Quality Metrics (Rosemount 5300 Series). Refer to the Rosemount 5300 Series Product Data Sheet (Document No. 00813-0100-4530) for details.

Antenna selection

- Cone antennas are recommended in most applications. Always use the largest possible antenna.
- Always ensure that the wetted materials are compatible with the process and that the antenna will withstand the application's temperature and pressure range.
- In case of corrosive tank media, consider using an antenna in exotic materials (Alloy C-275 or 400) with protective plate design(3) or, alternatively, a process seal antenna. Process seal antennas can also be used for applications with build-up or condensation.
- In case of turbulent surface conditions or foam, consider using a stilling well. For stilling well installation, refer to the Guidelines for Choosing and Installing Radar in Stilling Wells and Bypass Pipes Technical Note (Document No. 00840-0300-4024).
- Build-up on antennas can often be avoided or reduced by using heat-tracing or cleaning arrangements, such as purging adapter.

For more information, refer to the Rosemount Level Instrumentation Brochure (Document No. 00803-0100-4161).

(1) Valid for coaxial and single rigid probes.
(2) Valid for rigid and flexible single probes.
(3) Valid for cone antennas.

2.5 Solids measurement

Solids generally provide a difficult measuring environment with low dielectric products in tall tanks, where pull forces may act on the probe, and dust, steam, or risk of coating are often present. In addition, the surface is not flat and the angle of repose tends to change. As a result, the signal levels are often very low, and installation is of utmost importance.

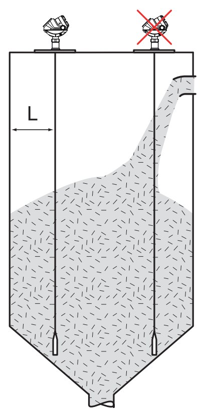
2.5.1 Rosemount 5303

Adding to the installation considerations described in “Tank installations” on page 22, when measuring solids, it is also important to consider the following:

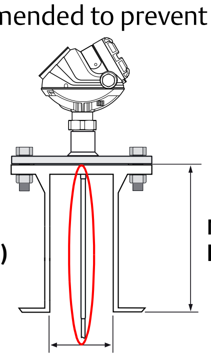
- Mount the probe as far away as possible from filling and emptying ports. This will minimize load and wear, and will help to avoid disturbances from the incoming product

Figure 2-20. Rosemount 5303 solids recommended mounting position

For flexible single lead probes, the minimum clearance to the tank wall (L) or obstruction is 4 in. (10 cm) in the case of smooth metallic walls, and 20 in. (50 cm) in the case of disturbing objects, rugged metallic or concrete/plastic walls.

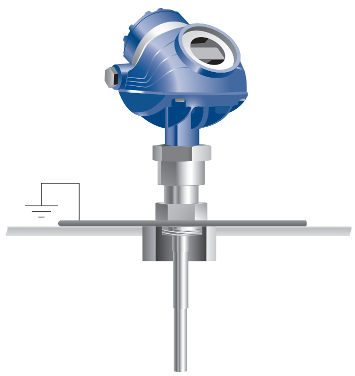


- Installing the probe at about 1/3 to 1/2 of the silo radius is recommended to compensate for measurement errors caused by centered filling of the material cone.
- The minimum recommended probe distance to tank wall or disturbing object is 20 in. (50 cm), unless the wall is comprised of smooth metal. Then the distance is 4 in. (10 cm). In any case, the probe should not be able to touch the wall of the tank during operation.
- The maximum recommended nozzle height is nozzle diameter + 4 in. (100 mm).
- When nozzles are more than 4 in. (100 mm) in height, a Long Stud (LS option) is recommended to prevent the probe from contacting the nozzle.



- Probe installation should occur when the silo is empty, and the probe should be regularly inspected for damage.
- Avoid 10-in. (250 mm) / DN250 or larger diameter nozzles, especially in applications with low dielectric constant.
- For environments where electrostatic discharges are likely to occur, e.g. plastics, it is recommended that the probe end is grounded with a proper grounding connection (R < 1Ω).
- In case of non metallic tanks, a Rosemount 5303 should be mounted with a metal plate of minimum 8 in. (200 mm) diameter. Use metal shielding for the conduit connections.

Figure 2-21. Installation with metal sheet in non-metallic vessels

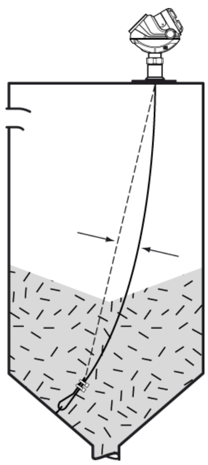


- In the case of bunkers with a concrete roof, a Rosemount 5303 should be installed flush with the inner roof surface or in a nozzle insert

Figure 2-22. Installation in concrete silo with metal shielding

- When probes are anchored, the forces are two to ten times greater than with free-hanging probes. To prevent an extremely high tensile load when fixing the probe, and to reduce the risk of probe breakage, the probe must be slack. Select a probe longer than the required measuring range so that there is a sag in the middle of the probe that is greater than or equal to $1^1/_2$ in. per 10 feet (1 cm per m) of the probe length

Figure 2-23. Fixing probe with slack



- For applications with a probe length longer than 115 ft. (35 m), please consult factory
- Consider using a non-contacting radar for abrasive media that can wear out the probe

For solids measurement, a Rosemount 5300 Series with Signal Quality Metrics (SQM) is recommended to help monitor possible build-up on probe. Use the ‘Measure and Learn’ function to reduce the impact of possible stationary disturbances in the tank. The Rosemount 5300 Series solids measurement might require activation of the Probe End Projection (PEP) function. See pages 47, 39, and 48 for details on how to activate SQM, Measure and Learn, and PEP.

2.5.2 Rosemount 5600 Series

The Rosemount 5600 Series can be used in tanks up to 165 ft (50 m).

As solids generally provide a difficult measuring environment and the signal levels are often very low, installation is of utmost importance. Antenna selection and its location in the tank are the keys to success.

Step 1: antenna selection

Figure 2-24. Parabolic antenna with a PTFE bag

Parabolic antenna with a PTFE bag:

- ideal for dusty applications
- the best choice for long distances
- can handle weak surface reflection
- positionable towards surface
- the PTFE bag prevents dust build-up at the antenna

Figure 2-25. Parabolic antenna

Parabolic antenna:

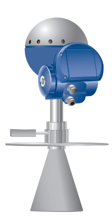
- the best choice for long distances
- can handle weak surface reflection
- positionable towards surface

Figure 2-26. 8-in. Cone antenna

8-in. Cone antenna

- suitable for distances of less than 50 ft (15 m)
- stronger surface reflection than in the case of smaller cones

Figure 2-27. 8-in. Cone antenna with flushing adapter

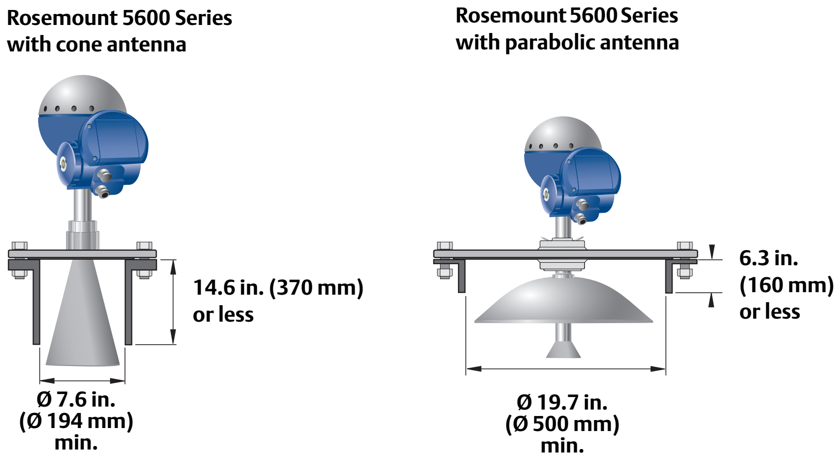


8-in. Cone antenna with flushing adapter

- ideal for dusty applications
- suitable for short distances of less than 50 ft (15 m)
- stronger surface reflection than in the case of smaller cones

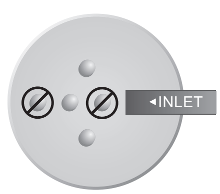
Step 2: tank connection

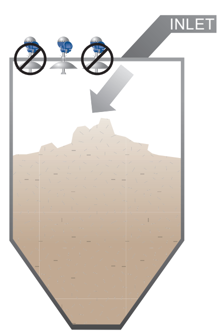
Figure 2-28. Rosemount 5600 Series with cone/parabolic antenna



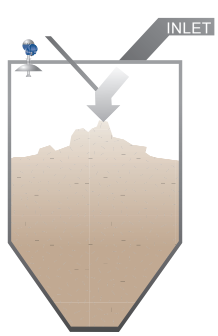
HINT:
If the signal is dampened by heavy condensation at the antenna, it often helps to insulate the nozzle. This minimizes the temperature disparity between the internal and ambient temperature. Installing the antenna so that it is inside the vessel helps to eliminate the chance of condensation.

Step 3: radar location



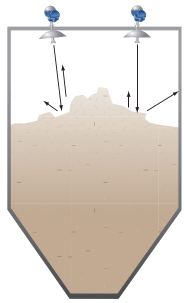


- The radar signal must never be shaded by the inlet nor the injected product.
- The radar should not be mounted in the center of the silo. It should always be mounted as close to the silo center as possible. A general practice is to mount the radar at $^2/_3$ tank radius from tank wall.



- A deflection plate might need to be installed at the inlet point in order to deflect the product stream away from the antenna.

Step 4: inclination of antenna



- If the surface echo is weak, the parabolic antenna can be inclined 0.5° to 2° towards the surface slope in order to increase the reflected signal.

NOTE:
Too great of an angle can create problems in detecting surface echo at the bottom region. The angle of the slope differs during filling and emptying. Therefore, monitor the entire cycle in order to verify and determine an optimum antenna inclination.

Table 2-10. Sample solid applications where non-contacting radar is preferred over GWR

Applications(1)	Common Characteristics					PTFE Bag Recommended (2)
	Particle Size			Vapor Space		
	Dust or Powder	Small (<1 in.)	Larger (>1 in.)	Dust	Steam or Condensation	
Wood chip bins(3)	Yes	Yes	Yes	Yes	Possible	Yes
Grain silo - small kernel grains(3)	Yes	Yes	No	Yes	No	Yes
Grain silo - large kernel grains	No	Yes	No	No	No	No
Lime stone silo	No	Yes	Yes	Possible	No	No
Cement - raw mill silo(4)	Yes	Yes	No	Yes	No	Yes
Cement - finished product silo(4)	Yes	Yes	No	Yes	No	Yes
Coal bin(5)	Yes	Yes	Yes	Yes	Yes	No
Saw dust	Yes	Yes	No	Yes	No	Yes
High consistency pulp stock	No	No	No	No	Yes	No
Alumina	Yes	Yes	No	Yes	No	Yes
Salt	No	Yes	Yes	No	No	No

(1) *These applications (except salt) typically involve tall vessels and therefore require the parabolic antenna option. The 8-in. cone antenna option can be used in the salt application where the vessel height is less than 50 ft. (15 m).*
(2) *The PTFE bag is only available for the parabolic antenna. If a cone antenna is used, consider the flushing connection option.*
(3) *For interstice silos, the antenna can be inclined 0.5 in. to 2 in. towards the surface slope.*
(4) *For interstice silos, the radar must be installed so that the radar signal clearly passes internal support structures without interferences.*
(5) *Clean the antenna regularly.*

Step 5: software settings

- Note that solids applications in general are difficult, therefore Emerson Process Management has developed a special solids mode in the radar database. This means that the radar database configuration is optimized for solids measurements when the “solids” check-box is selected in the Rosemount Radar Master (RRM) setup window. Additional adjustments of the database might in some cases become necessary. In such cases, contact the factory for further details on how to proceed.
- Some solids build up electrostatic discharges, which might result in explosion risks. Therefore, the Rosemount 5600 Series has been approved for use in such environments. See the Rosemount 5600 Series Radar Transmitter Product Data Sheet (00813-0100-4024) for detailed information about approvals. Also note that the PTFE bag is NOT approved for use in hazardous area.

For more information on measuring solids, refer to the Guided Wave Radar in Solid Level Applications (Document No. 00840-2300-4811), and Measuring Solids with a Rosemount 5600 Series Non-Contacting Radar (Document No. 00840-0100-4024) Technical Notes.

Section 3 Commissioning

3.1 Safety messages

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Please refer to the following safety messages before performing an operation preceded by this symbol.

⚠ WARNING

Explosions could result in death or serious injury:

Verify that the operating environment of the transmitter is consistent with the appropriate hazardous locations certifications.

Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

Do not remove the gauge cover in explosive atmospheres when the circuit is alive.

Failure to follow safe installation and servicing guidelines could result in death or serious injury:

Make sure only qualified personnel perform the installation.

Use the equipment only as specified in this manual. Failure to do so may impair the protection provided by the equipment.

Do not perform any service other than those contained in this manual unless you are qualified.

Process leaks could result in death or serious injury.

Make sure that the transmitter is handled carefully. If the process seal is damaged, gas might escape from the tank if the transmitter head is removed from the probe.

High voltage that may be present on leads could cause electrical shock:

Avoid contact with leads and terminals.

Make sure the main power to the transmitter is off and the lines to any other external power source are disconnected or not powered while wiring the gauge.

Probes covered with plastic and/or with plastic discs may generate an ignition-capable level of electrostatic charge under certain extreme conditions. Therefore, when the probe is used in a potentially explosive atmosphere, appropriate measures must be taken to prevent electrostatic discharge.

3.2 Introduction

The transmitter installation should be carried out as described in the Quick Installation Guide that is enclosed with every transmitter. Even though the transmitter may be installed on the bench, it must be configured to the actual process conditions. For the Rosemount GWR transmitters, it is important not to bend the probe during any part of the installation. It may be necessary to shorten the probe, mount a centering disk, or anchor the probe during the mechanical installation. For more information, see the Rosemount 3300 and 5300 Reference Manuals (Document No. 00809-0100-4811 and 00809-0100-4530).

For the Rosemount 5300 Series with QS Prior-Use option in Safety Instrumented Systems (SIS) refer to the Quick Installation Guide (Document No. 00825-0100-4530) and the Reference Manual (Document No. 00809-0100-4530) for instructions. Beside these required steps, the procedures below are recommended as best practices.

Recommendations for grounding are available in the Grounding Best Practices and Transient Protection for Rosemount Radar Transmitters Technical Note (Document No. 00840-2700-4811).

3.3 Functions of procedures to include during commissioning process

Table 3-1. Chamber installations

Function	Rosemount Series
Trim Near Zone (TNZ)	Rosemount 3300 Series Rosemount 5300 Series
Upper Null Zone (UNZ)	All
Setting range values	All
Remote housing	Rosemount 5300 Series
Static Vapor Compensation (SVC)	Rosemount 5300 Series
Dynamic Vapor Compensation (DVC)	Rosemount 5300 Series
Signal Quality Metrics (SQM)	Rosemount 5300 Series
Safety Instrumented Systems (SIS)	Rosemount 5300 Series(1)

(1) See the Rosemount 5300 Series Reference Manual (Document No. 00809-0100-4530).

Table 3-2. Tank installations

Function	Rosemount Series
Trim Near Zone (TNZ)	Rosemount 3300 Series Rosemount 5300 Series
Upper Null Zone (UNZ)	All
Measure and learn	Rosemount 5400 Series
Configuration for process conditions	All
Signal Quality Metrics (SQM)	Rosemount 5300 Series Rosemount 5400 Series
Safety Instrumented Systems (SIS)	Rosemount 5300 Series(1)
Store backup	All

(1) See the Rosemount 5300 Series Reference Manual (Document No. 00809-0100-4530).

Table 3-3. Solids measurement

Function	Rosemount Series
Trim Near Zone (TNZ)	Rosemount 5300 Series
Upper Null Zone (UNZ)	Rosemount 5300 Series Rosemount 5600 Series
Probe End Projection (PEP)	Rosemount 5300 Series
Configuration for process conditions	Rosemount 5300 Series Rosemount 5600 Series
Safety Instrumented Systems (SIS)	Rosemount 5300 Series(1)
Store backup	All

(1) See the Rosemount 5300 Series Reference Manual (Document No. 00809-0100-4530).

3.3.1 Trim Near Zone (GWR transmitters)

The Rosemount 3300 and 5300 Series are equipped with a firmware functionality that minimizes the Upper Transition Zone based on actual mounting conditions. Trimming means that the measurement performance in the near zone is maintained even under these conditions and prevents false echo indication. This may be the case, for example, when a single lead probe is installed in a chamber or if there are disturbing obstacles in the near zone. As best practice in power applications, where short chambers are often used, the Trim Near Zone (TNZ) function is advised. This function is especially recommended together with remote housing. For the Rosemount 3300 Series TNZ instructions, refer to the Rosemount 3300 Series Reference Manual Section 6 "Service and Troubleshooting" (Document No. 00809-0100-4811).

NOTE:
The TNZ function should only be used for reducing impact from stationary disturbances. It is not suitable for occasional disturbances. For firmware version 2.A2 (released April 2009) the TNZ is not possible in combination with narrow nozzles, as defined below:
- 2 in. (50 mm) < Nozzle height < 12 in. (300 mm)
- Nozzle diameter < 2 in. (50 mm) for all single probes except 13 mm single rigid
- Nozzle diameter < 3 in. (75mm) for 13 mm single rigid

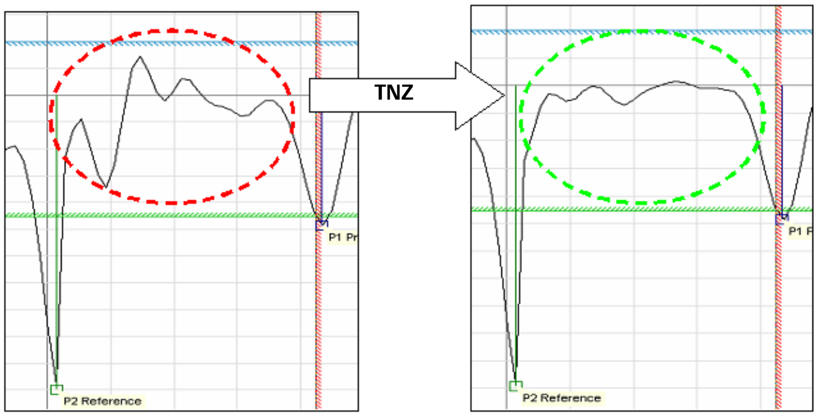
NOTE:
The TNZ function cannot be used with the Rosemount 5300 Series DVC option. The TNZ function is automatically blocked in RRM when DVC is activated.

To activate the TNZ function, ensure that the tank or chamber is empty, or that the (upper) product is not closer than 43 in. (1.1 m). Then execute the TNZ command:

RRM > Advanced > Near Zone > Trim Near Zone

See the Rosemount 5300 Series Reference Manual for details (Document No. 00809-0100-4530).

Figure 3-1. Echo curve before and after TNZ

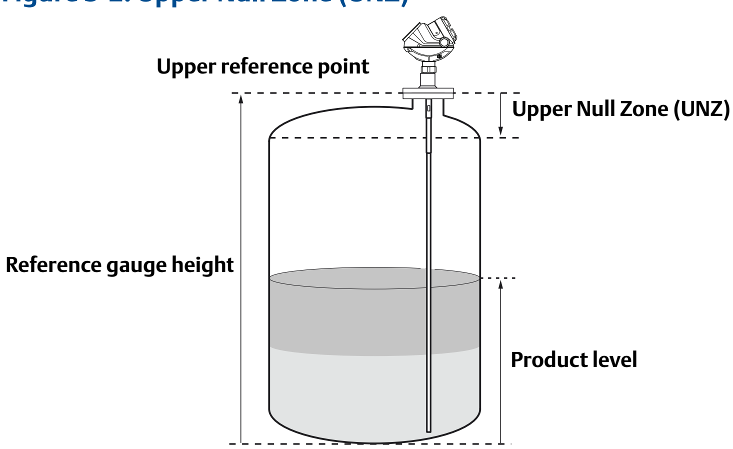


NOTE:
The effect of TNZ is only visible when an echo is present in the near zone.

3.3.2 Changing the Upper Null Zone (UNZ)

Measurements are not performed within the Upper Null Zone (UNZ). By setting the UNZ parameter to zero, measurements can be performed in the region close to the flange (near zone).

Figure 3-2. Upper Null Zone (UNZ)



If there are measurements desired in the upper part of the tank, use the Trim Near Zone function to optimize the echo curve in that region, see "Trim Near Zone (GWR transmitters)" on page 37. If the desired measurement range is below the near zone, or if disturbing objects are located within the near zone, the UNZ parameter can be used to avoid false measurements contained within the UNZ area.

- Rosemount 5300, 5400, and 5600 Series

  RRM > *Tank* > *Probe* > *Upper Null Zone* (enter desired value in field)
  RRM > *Echo Curve* > *Configuration Mode* (Drag & Drop UNZ line)

- Rosemount 3300 Series

  Radar Configuration Tool > *Setup* > *Tank Config tab* (click *Receive Page*) > *Upper Null Zone* (enter desired value in field and click *Send Page*)

3.3.3 Measure and learn function

The Rosemount 5300 and 5400 Series have a firmware functionality to automatically adjust threshold settings to make the measurement more robust. The Measure and Learn function in RRM automatically creates an Amplitude Threshold Curve (ATC) used by the Rosemount 5300 and 5400 Series transmitter to find the surface pulse. For best practice, use the Measure and Learn function in the empty tank.

RRM > *Echo Curve* > *Configuration Mode*> *Learn*

Always review the threshold settings at operating conditions. See "Echo curve constituents" on page 65, and the Rosemount 5300 or 5400 Series Reference Manuals for details (Document No. 00809-0100-4530 or Document No. 00809-0100-4026).

3.3.4 Vapor compensation

For high pressure steam applications, the DC of the vapor increases (DC of air is 1). Therefore, vapor compensation is required for accurate level measurement. The table below provides examples of error in level measurement reading with incorrect static vapor compensation.

The Rosemount 5300 Series is available with both static and dynamic compensation. If the static compensation is used, is important that the correct DC value is entered. If dynamic compensation is used, the transmitter automatically compensates for changes in vapor dielectrics.

Table 3-4. Level reading errors during shutdown, with fixed saturated water steam correction activated

Entered Vapor DC	Error in reading, when actual Vapor DC is 1		Offset in reading, if Vapor DC is configured correctly
	Surface at 15 in (380 mm) from flange	Surface at 30 in. (760 mm) from flange	
1.001	0 in. (0 mm)	0 in. (0 mm)	0 in. (0 mm)
1.022	0.2 in. (4 mm)	0.3 in. (8 mm)	0 in. (0 mm)
1.180	1.3 in. (33 mm)	2.6 in. (65 mm)	0 in. (0 mm)

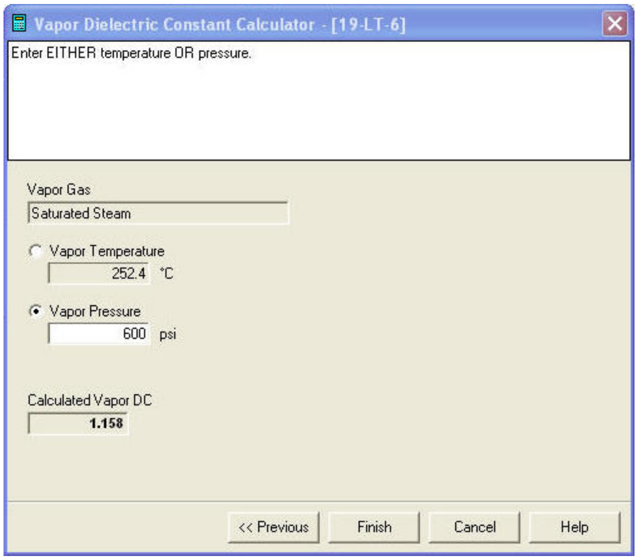
NOTE:
When performing a verification at ambient pressure and temperature conditions, always set vapor dielectric to 1 (applies to static vapor compensation). Otherwise, the level reading will be incorrect. Also see "Static Vapor Compensation (Rosemount 5300 Series)".

Static Vapor Compensation (Rosemount 5300 Series)

For high pressure saturated steam applications the specific properties of water and saturated steam must be taken into account when commissioning the transmitter. The standard version of a Rosemount 5300 Series level transmitter can be configured for static compensation of vapor by manually entering the dielectric constant of vapor, to compensate for the error induced by the saturated steam. For applications with a varying pressure and/or temperature, certain models of the Rosemount 5300 Series have a built-in function (DVC), used along with a special probe, that automatically compensates for varying vapor dielectric constants. See section below for details.

RRM > Setup > Tank > Environment > Advanced Mode > Vapor Dielectric Constant Calculator

Figure 3-3. RRM Vapor Dielectric Constant Calculator



NOTE:
The saturated steam compensation is fixed and will only adjust the level reading at specified conditions. This means that the transmitter shows a correct level reading during operation, but not during startup and shutdown, when these conditions are not fulfilled. See Table 3-4 on page 39.

Dynamic Vapor Compensation (Rosemount 5300 Series)

While factory calibration of the 3 in. (75 mm) and 4 in. (100 mm) DVC probe and transmitter is possible, it may be necessary to perform this calibration in the field if new electronics are required or other options, such as remote head connection, are added at a later date.

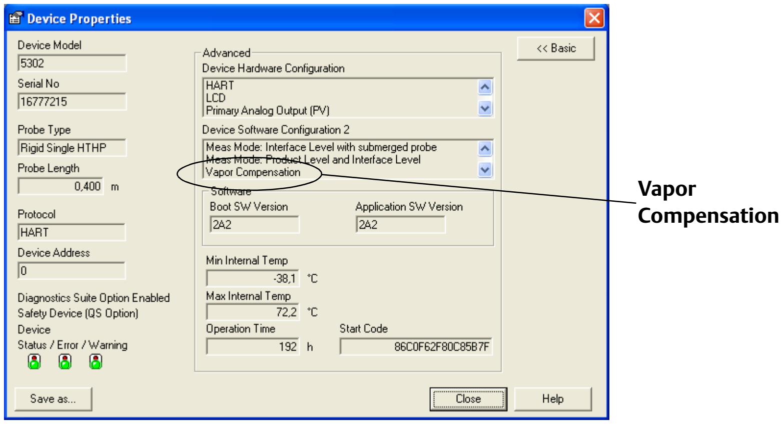
2 in. (50 mm) DVC probes must be field calibrated at ambient conditions.

For the Rosemount 5301 with DVC option it is important that the vapor compensation function is calibrated after installation. The calibration must be performed with an empty chamber at ambient conditions.

The Rosemount 5300 Series with DVC uses a reference reflector mounted on the probe at a certain distance to estimate the dielectric constant of the vapor. The transmitter knows where the reference reflector pulse should have been if there were no vapor present. However, since there is vapor in the tank, the reference reflector pulse will appear beyond the actual reflector point. The distance between the actual reflector point and the apparent reflector point will be used to calculate the vapor dielectric constant. The calculated dielectric constant is then dynamically used to compensate for changes in vapor dielectric constant and eliminates the need to do any compensation in the control system. To check if the DVC function is supported:

RRM > Device > Properties (If *Vapor Compensation* is mentioned in the *Device Software Configuration 2* list, the device supports vapor compensation).

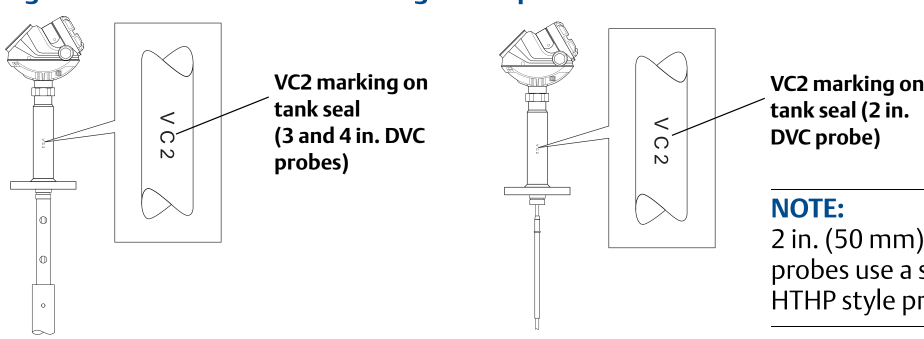
Figure 3-4. Check if DVC is supported



NOTE:
Vapor compensation is supported for product level measurement mode only.

NOTE:
For the 3 in. (75 mm) and 4 in. (100 mm) flange DVC probes, coaxial HTHP equipped with a reference reflector is the only probe that supports vapor compensation. The probe is marked *VC2* as shown in Figure 3-5.

Figure 3-5. HTHP with VC2 marking on the probe



NOTE:
2 in. (50 mm) flange DVC probes use a single rigid HTHP style probe.

- Probes up to 13.1 ft (4 m) length are supported
- Pipe / chamber is the only supported mounting type. Supported pipe inner diameters are 2(1), 3, and 4 in. (5, 7.5, and 10 cm)
- PEP is disabled when vapor compensation is enabled
- TNZ shall not be used when DVC is used

(1) *A 3 or 4 in. (75 or 100 mm) diameter chamber is recommended as best practice, but the GWR can also be mounted in a 2 in. (50 mm) chamber.*

Installation setup

It is important that the vapor compensation function is calibrated after installation and after the basic configuration is complete. The basic configuration includes setup of the unit in a chamber installation and the use of a remote housing connection. Before calibration, do the following:

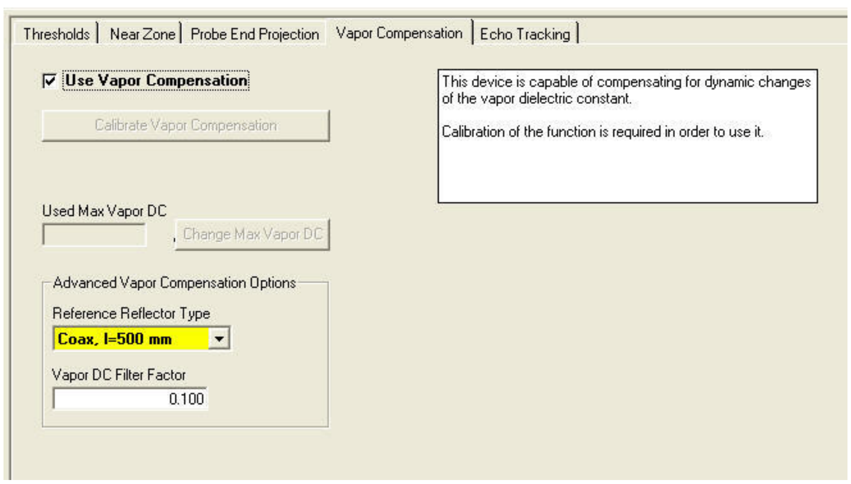
- The surface level must be at least 19.7 in. (0.5 m) below the end of the reflector (36 in. (0.9 m) or 39.7 in. (1.0 m) below the flange, depending on reflector/probe length). Note that it is recommended to empty the pipe/chamber and to ensure that it is cleared from any steam and/or condensation remains.
- Perform the calibration at ambient pressure and temperature conditions, when the vapor dielectric constant is close to 1.0.

To calibrate DVC, choose one of the following:

RRM > *Guided Setup* > *Device Specific Configuration* (if the configuration is recommended)

RRM > *Setup* > *Advanced* > *Vapor Compensation tab* > Click the *Calibrate Vapor Compensation* button (Make sure *Use Vapor Compensation* is selected)

Figure 3-6. Calibrate DVC



After calibration, do the following:

- Verify that the reference reflector echo is registered in RRM, at correct length, and that no error messages are present in the device diagnostics. The echo from the reference reflector end can be viewed in the echo curve in RRM.

  RRM > *Echo Curve*

RRM > *Tools* > *Diagnostics*

Refer to the Rosemount 5300 Series Reference Manual (Document No. 00809-0100-4530), and the Using Guided Wave Radar for Level in High Pressure Steam Applications Technical Note (Document No. 00840-0100-4530) for details.

3.3.5 Remote housing (GWR transmitters)

If a remote housing is added to a unit after the DVC calculation is done, the unit needs to be recalibrated.

When using remote housing, the remote connection length should be configured. If the remote housing is ordered with a transmitter, it is configured in the factory. For more details, refer to the Rosemount 5300 Series Reference Manual "Appendix D Remote Mounting" (Document No. 00809-0100-4530).

RRM > *Setup* > *Tank* > *Probe tab* (select applicable *Remote Housing length*)

3.3.6 Setting range values for chambers - options

There are different options to set the range values in chamber installations to get the desired output. The options are described below.

For displacers, the output span corresponds to the displacer length, with Lower Range Values (LRV) and Upper Range Values (URV) representing the bottom and top of the displacer. In side-to-side chambers, this corresponds to center-of-the-pipe connections to the vessel.

For the level measurement to correspond to a designated nominal zero value such that it reads positively and negatively from that point, some modifications are required:

- the tank height (reference gauge height) should be set as the distance from the flange to the nominal level point
- the URV is the positive distance from the nominal reference point to the desired upper range limit
- the LRV is the negative distance from the nominal reference point to the lower range limit
- the probe length is the actual probe length

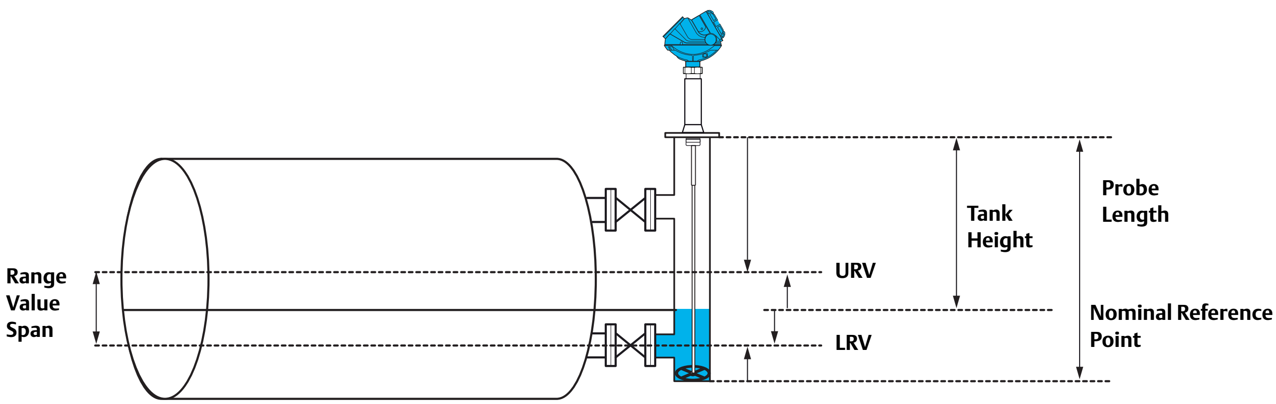
Option 1 - Matching the output of +/- deviation from the nominal reference point

Choose level as primary variable to show on the local display. For example, if a GWR is replacing a 14 in. (356 mm) displacer, the span would be -7 in. (-178 mm) to +7 in. (+178 mm).

Table 3-5. Option 1 example:

Gauge height	distance to nominal reference point	57 in. (1448 mm)
Probe length	probe length	87 in. (2210 mm)
URV	nominal reference point +7	7 in. (178 mm)
LRV	nominal reference point -7	-7 in. (-178 mm)
Special	tank presentation	uncheck negative value

Figure 3-7. Range values for chambers - option 1



NOTE:
This output option requires an extra configuration of the Holding Register Sip-Tank Presentation to enable negative output values.

RRM > *Service* > *Enter Service Mode* (password admin)

Service > *View Holding Registers* >*Sip (click Read)* > *TankPresentation* > *(double click on bit field) Bit 8 Show negative level as zero* (uncheck box and click *Store*)

Service > *Exit Service Mode*

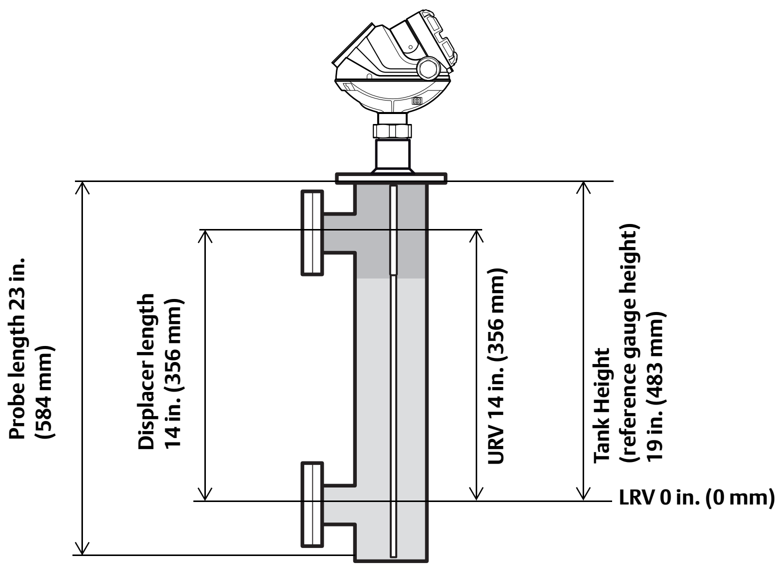
Option 2 - Setting LRV to 0 in. (0 mm) at the lower tap

The tank height should be set to the distance to the zero level point. In this example, it is the lower side-pipe, located 19 in. (483 mm) below the reference point. Output range values will equal the pipe connection heights relative to the zero level point. LRV should be set at 0 in. (0 mm), the URV should be set at 14 in. (356 mm), and the probe should be set to the correct probe length.

Table 3-6. Option 2 example:

Gauge height	distance to LRV	19 in. (483 mm)
Probe length	probe length	23 in. (584 mm)
URV	distance between connections	14 in. (356 mm)
LRV	center of bottom connection	0 in. (0 mm)

Figure 3-8. Range values for chambers - option 2



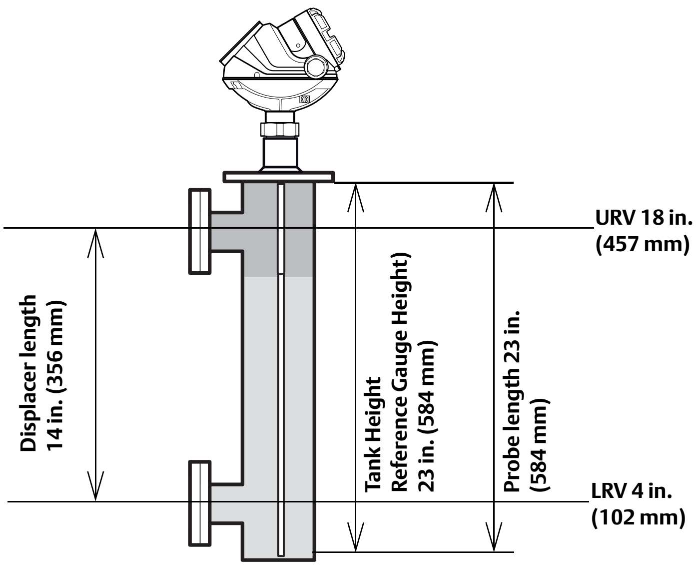
Option 3 - Matching displacer output

The tank height (reference gauge height) and the probe length should be set to the same value. The LRV is the distance from the bottom of the probe to the lower tap. The URV is the LRV plus the distance to the upper tap. In this example, tank height (reference gauge height) equals the probe length of 23 in. (584 mm), the LRV is 4 in. (102 mm), and the URV is 18 in. (457 mm).

Table 3-7. Option 3 example:

Gauge height	same as probe length	23 in. (584 mm)
Probe length	probe length	23 in. (584 mm)
URV	LRV + distance between connections	18 in. (457 mm)
LRV	end of probe to center of lower connection	4 in. (102 mm)

Figure 3-9. Range values for chambers - option 3



3.3.7 Signal Quality Metrics (Rosemount 5300 and 5400 Series)

Signal Quality Metrics (SQM) indicates the surface signal integrity compared to the noise. It can be used to schedule maintenance to clean the probe or detect and monitor turbulence, boiling, and foam.

The Rosemount 5300 Series with Diagnostics Suite option and the Rosemount 5400 Series have the SQM function. See the Rosemount 5300 Series and Rosemount 5400 Series Reference Manuals for set-up details (Document No. 00809-0100-4530 and 00809 -0100-4026).
To view SQM in RRM:

RRM > *Tools* > *Device Display* > *Signal Quality Metrics*

NOTE:
If SQM is not supported or disabled, the signal quality and surface/noise margin will always be set to 0.

SQM can be shown on the LCD panel, see "Operation" in the Rosemount 5300 Series and Rosemount 5400 Series Reference Manuals (Document No. 00809-0100-4530 and 00809-0100-4026). SQM can be assigned to transmitter variables (SV, TV, or QV). In RRM, this can be done by selecting:

RRM > *Setup* > *Output*

Variables can be sent to the Distributed Control System (DCS) to trigger an alarm. Suitable trigger levels vary from application to application. Guidelines for appropriate values can be determined by logging SQM over time and viewing minimum/maximum values. The signal quality alarm trigger value should be at least 1, but a better guideline is 2-3.

3.3.8 Configuration for process conditions

The Rosemount 5400 and 5600 Series have advanced configuration options for different process conditions, such as *Foam*, *Turbulent Surface*, *Rapid Level Changes*, or *Solid Product* (only Rosemount 5600 Series). This means that the transmitter database configuration is optimized for the process condition selected e.g. solids measurements. Additional adjustments of the database might in some cases become necessary for solids measurement. In such cases, contact a Rosemount representative for further details on how to proceed.

By selecting the suitable option for the process condition, the measurement parameters are optimized for the selected condition.

RRM > *Advanced* > *Process condition*

NOTE:
Select only one, maximum two process conditions, otherwise the effect may cancel out each other.

For the Rosemount 5300 Series in applications with rapid level changes, such as a flash tank, measurement parameters can be adjusted to enable a faster response time. Select *Rapid Level Changes* under *Process Condition*, and set *Damping Value* to 0 s (default value is 2 s).

RRM > *Tank* > *Rapid Level Changes* (Under *Process Condition*)

RRM > *Advanced* > *Echo Tracking* > *Damping Value*

3.3.9 Probe End Projection (Rosemount 5300 Series solids measurement)

Probe End Projection (PEP) handles long measuring ranges on media with low dielectrics, such as solids. If the signal is not reflected at the surface, the Rosemount 5300 Series uses the probe end as a reference to calculate the actual level.

When the surface echo is lost, use the probe end echo as reference to calculate the surface echo position

See the Rosemount 5300 Series Reference Manual "Appendix C Advanced Configuration" for configuration instructions (Document No. 00809-0100-4530).

This probe end echo must be in a consistent position. It must either be free hanging at all times to create a negative pulse or it must be attached such that a positive pulse is created.

NOTE:
This function is not compatible with SQM or DVC.

Surface threshold

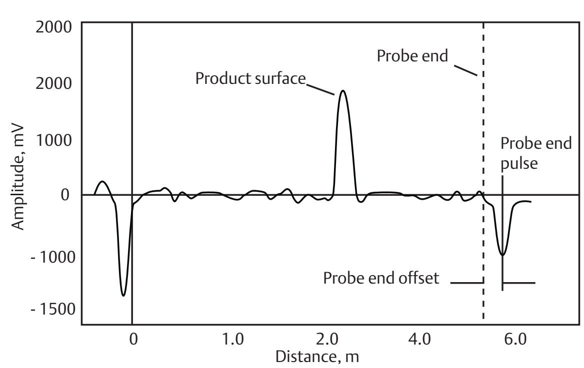
A true surface echo calibrates the Dielectric Constant (DC) used by PEP and a false surface echo miscalibrates the DC used by PEP. Therefore, set the surface threshold as low as possible without ever allowing false echoes to break it. For the probe end threshold, automatic setting is mostly OK, but must be low enough to ensure probe end pulse detection. It is recommended to perform the procedure once with an empty tank, and once with product in the tank.

NOTE:
Assure that the tank settings *Mounting Type*, *Probe Type*, and *Probe Length* have been assigned correct values before continuing.

In RRM, PEP is set using:

RRM > Setup > Advanced > Probe End Projection

Figure 3-10. Probe end projection



3.3.10 Store backup and verification files

As the last step of the commissioning procedure, it is recommended that both the transmitter settings and the echo curve be stored. For example, these can be used for subsequent transmitter verification or troubleshooting. Note that the echo curve should also be stored once more at operating conditions.

In RRM, configure the following:

RRM > *Device* > *Backup Config to file*
RRM > *Tools* > *Echo Curve* > *Record*

In Radar Configuration Tools, do the following:

Radar Configuration Tools > *View* > *Memory* > *All EE*

3.3.11 Write protect

A Rosemount 5300 and a 5400 Series transmitter can be password protected from unintentional configuration changes. The default password is 12345 and it is recommended that this password is not changed to facilitate service and maintenance of the transmitter.

In RRM:

Tools > *Lock / Unlock Configuration Area*

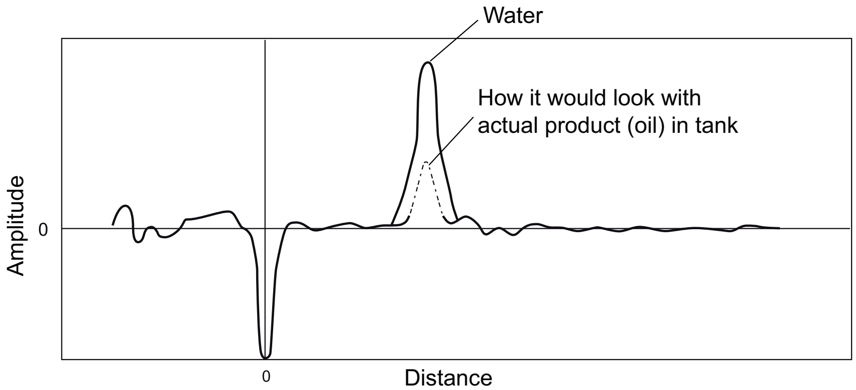
3.3.12 On the bench test (optional)

Sometimes the actual process is not available and the transmitter is pre-commissioned on the bench. In this case, the level is often simulated using metal-plates, water, or other targets. Although, these tests provide a basic verification of the transmitter, they do not verify that the transmitter functions properly at the actual process conditions. Bench tests complement verification tests, but do not replace them. The instructions in “Measurement validation” on page 51 should be followed and the bench test is considered optional. One of the largest differences between the simulated level and the actual level during operating conditions is the amplitude of the surface peak. For example, in a 4 in. (100 mm) chamber using the Rosemount 5300 Series transmitter and a single probe, the peak of water can be 10000 mV, while oil would be 2000 mV under the same conditions.

NOTE:
Never set the thresholds according to simulated level values since there is a major risk that the thresholds may be set too high.

Generally, it is advised to accept the automatic settings. If it is necessary to adjust the thresholds, do the adjustments the first time the process is started at actual operating conditions. Normally, the thresholds do not require any adjustments on the custom settings.

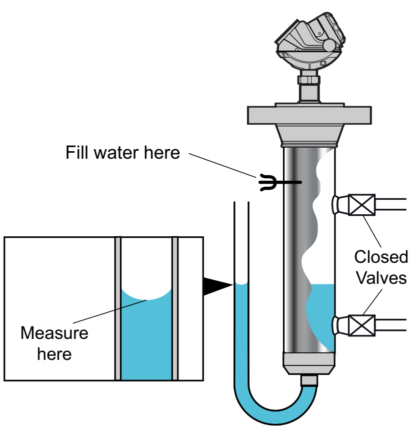
Figure 3-11. The difference between the amplitude of surface peaks in the case of simulated and actual liquid levels



Example

A Rosemount 5300 Series transmitter mounted in a chamber can be verified by connecting flexible transparent tubing to the bottom drain, ensuring that there are no crimps or folds in the bend to impede the flow. The inlet-pipes are sealed by closing the valves, and filling the chamber with water using the upper vent hole (water can also be introduced through the bottom drain connection). The level is varied between the 4-20 mA set-points to verify that the basic transmitter settings have been configured correctly. Once the chamber is mounted on the actual tank and the process is started, a complete verification is carried out, see "Measurement validation" on page 51.

Figure 3-12. Verification of transmitter measurement in bridle application using tubing



Section 4 Measurement validation

4.1 Safety messages

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the following safety messages before performing an operation preceded by this symbol.

⚠ WARNING

Failure to follow these installation guidelines could result in death or serious injury.

Make sure only qualified personnel perform the installation.

Use the equipment only as specified in this manual. Failure to do so may impair the protection provided by the equipment.

Explosions could result in death or serious injury.

Verify that the operating environment of the transmitter is consistent with the appropriate hazardous locations certifications.

Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

Electrical shock could cause death or serious injury.

Use extreme caution when making contact with the leads and terminals.

High voltage that may be present on leads could cause electrical shock:

Probes covered with plastic and/or with plastic discs may generate an ignition-capable level of electrostatic charge under certain extreme conditions. Therefore, when the probe is used in a potentially explosive atmosphere, appropriate measures must be taken to prevent electrostatic discharge.

⚠ WARNING

Any substitution of non-authorized parts or repair, other than exchanging the complete transmitter head or probe assembly, may jeopardize safety and is prohibited.

Unauthorized changes to the product are strictly prohibited as they may unintentionally and unpredictably alter performance and jeopardize safety. Unauthorized changes that interfere with the integrity of the welds or flanges, such as making additional perforations, compromise product integrity and safety. Equipment ratings and certifications are no longer valid on any products that have been damaged or modified without the prior written permission of Emerson Process Management. Any continued use of product that has been damaged or modified without prior written authorization is at the customer's sole risk and expense.

4.2 Introduction

In this section, the steps of measurement validation at operating conditions are described. The measurement validation should be performed under operating conditions, and the actual liquid must be used to ensure the accuracy of the measurement data. The validation procedure outlined in this section can also be used as a suggestion of a proof test.

4.3 Measurement validation at operating conditions

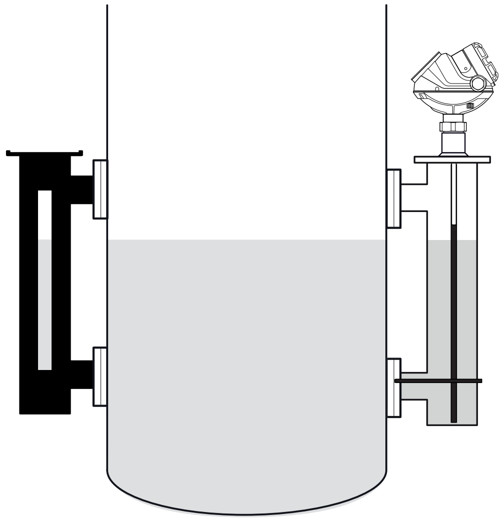
Once a Rosemount radar level transmitter has been installed and configured, it will continuously deliver measurements with a minimum of maintenance. The electronics are self-adjusting, so no re-calibration is needed. The outlined procedure is intended to be a part of the startup process, or used as a re-occurring functional check, to validate the integrity of the transmitter during actual operating conditions. If the verification fails, refer to Section 5: Troubleshooting procedures.

All of the steps in this sample verification procedure are independent and although it is not recommended, single steps may be omitted. Before you start the verification procedure, ensure that proper actions have been taken not to affect the safety or performance of the process. A checklist for the measurement validation process is provided on page 83.

Step 1: verify the correctness of level reading

At normal operating conditions, compare the transmitter level reading with an independent measurement. Unfortunately, it often happens that two independent measurements will not match up perfectly, but check the sanity and the acceptable deviation. See "Reconciling radar with other level measurements" on page 79 for more information. The independent measurement can be done using a number of different complementary devices, ranging from sight-glasses and hand-dipping to redundant differential-pressure and displacer. See "Sources of measurement error" on page 73, if deviation is unacceptable.

Figure 4-1. The verification of measurement data using a sight-glass

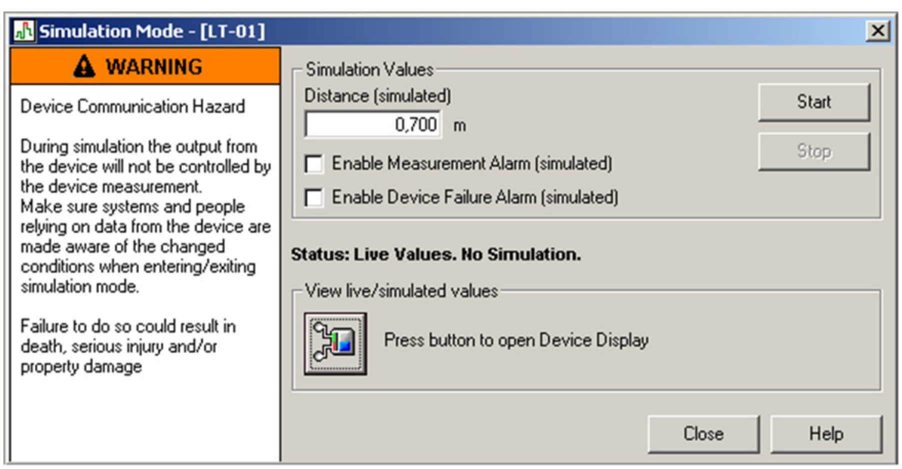


Step 2: analog output signal validation

Note that this section refers to 4-20 mA/HART units only. Ensure that the loop has been set to manual mode in the Distributed Control System (DCS) for the applicable transmitter. Use the transmitter's built-in simulation mode to verify the analog output settings. Output at least one arbitrary level and verify that the reading in the DCS match. To access the simulation mode in Rosemount Radar Master (RRM):

RRM > Tools > Simulation Mode

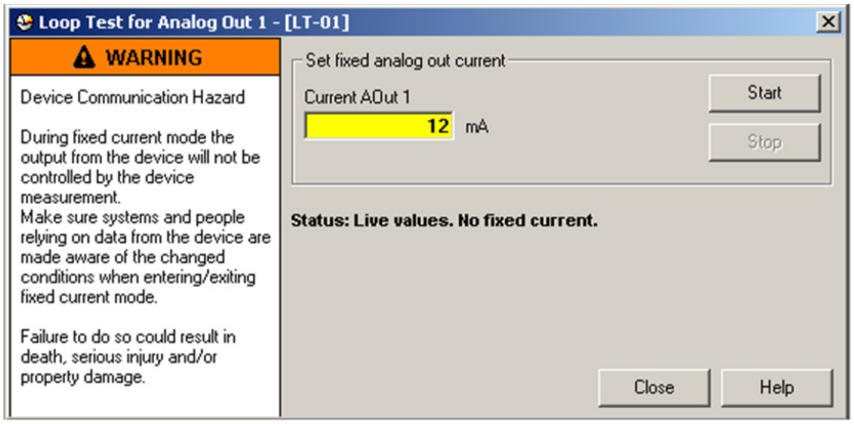
Figure 4-2. Simulation Mode



Also, or alternatively, activate the transmitter’s loop test function. Output 4, 12, and 20 mA and verify that the readings in the DCS match up. In RRM:

RRM > Output > Analog Out > Loop Test

Figure 4-3. Loop test for Analog Out 1



Step 3: echo-curve verification at operating conditions

At normal operating conditions, download and review the echo-curve according to the following steps:

1. *Check reference pulse amplitude and position*
   Compare the result against the previous plots, taken during commissioning, and previous verification rounds. Note that deviation of pulse amplitude and position may occur between plots taken at ambient conditions and operating conditions.

   For a Rosemount 5301 with DVC also verify that the reference reflector echo is visible.

NOTE:
The non-contacting radar has a positive reference pulse.

2. *Review peak amplitudes and threshold settings*
   Verify that the surface peak is visible and that the thresholds have been set according to the best practices in Section 5: Troubleshooting procedures. If possible, compare the current echo-curve with previously stored echo-curves taken during operating conditions. There should be no major differences.

3. *Store the echo-curve*
   Permanently store the echo-curve for future use, with re-occurring verification procedures.

Figure 4-4. GWR transmitter peak amplitudes and threshold settings

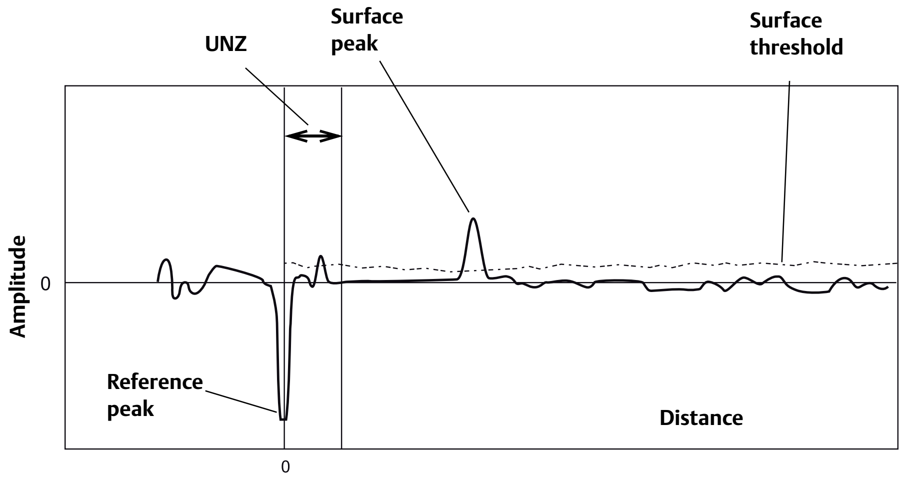
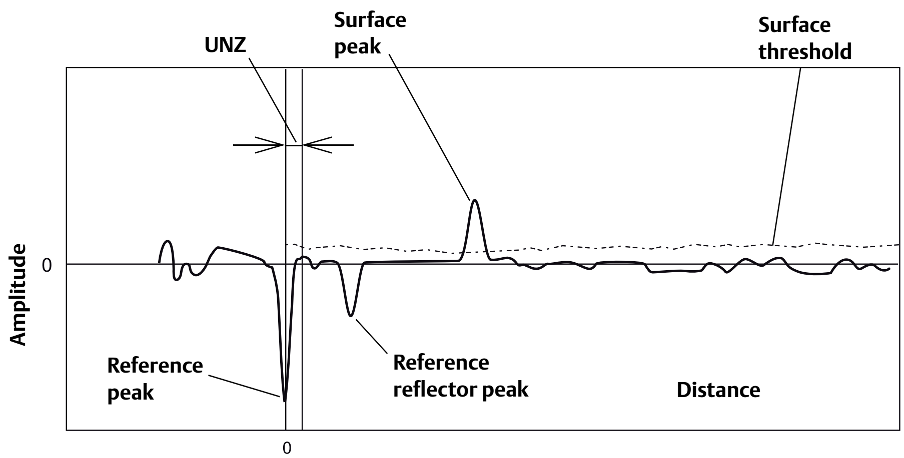


Figure 4-5. Rosemount 5300 Series with DVC, reference reflector peak and threshold settings

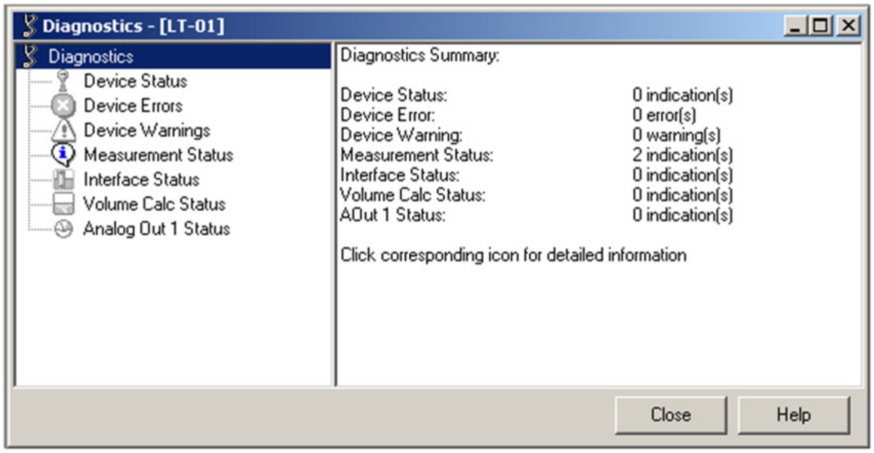


Step 4: transmitter diagnostics review

The transmitter contains valuable diagnostics that monitor the health of the device to make sure that it does not report any errors or warnings. For details on diagnostic messages refer to the transmitter reference manual. In RRM:

RRM > Tools > Diagnostics

Figure 4-6. Diagnostics

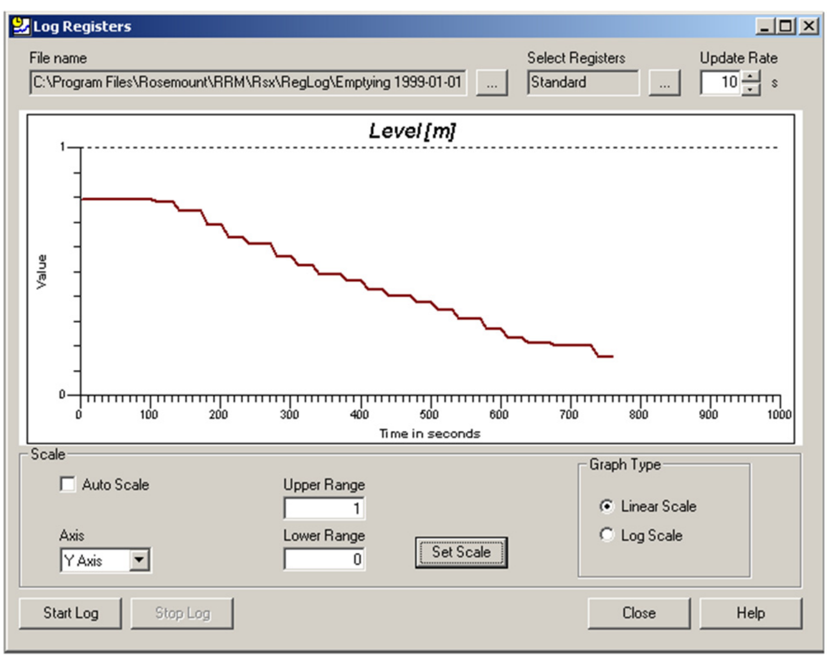


Step 5: monitor level while emptying

During Step 1, the current level (and/or interface) reading was verified. This step will verify that the transmitter correctly tracks the surface during the emptying of the tank. Begin by activating log functionality for the transmitter level output. Either the DCS-trend or a standalone tool can be used:

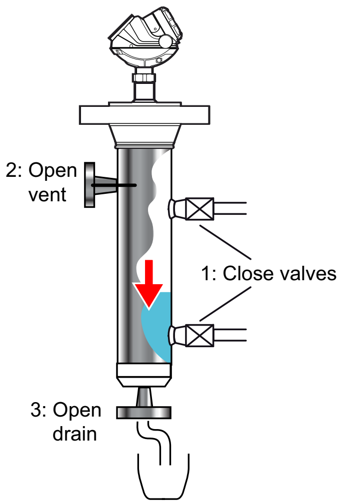
RRM > *Tools* > *Log*

Figure 4-7. Log Registers



Start emptying the tank or chamber making sure not to stop until it is completely empty. With a chamber, do not forget to close the process valves before draining.

Figure 4-8. Emptying a tank or chamber



Finally, review the level trend for accuracy.

Step 6: echo-curve verification with empty tank

When the tank or chamber is empty, download and review the echo-curve according to the following steps:

1. *Compare echo-curve with previous plots*
   Compare the echo-curve with previous plots, taken during commissioning. There should be no major differences. Especially make sure to review:
   - the amplitude and position of the reference pulse
   - if all noise is below the threshold
   - the amplitude and position of the bottom or probe-end pulse
2. *Store the echo-curve*
   Permanently store the echo-curve for future use, with re-occurring verification procedures.

Step 7: monitor level while filling

Repeat Step 5, but fill the tank or chamber instead of emptying it.

4.4 Operation and maintenance - proof testing for SIS

The Rosemount 5300 Series Prior-Use option must be tested at regular intervals to confirm that the overfill and empty tank protection function result in the desired system response. The required proof test intervals are dependent on the configuration of the transmitter and the process environment. The Rosemount 5300 Series is designed to have a 5-year proof test interval assuming it represents the typical 35% of the SIF PFD_{AVG}. However, it is the responsibility of the operator/owner of the system to determine the sufficient time interval and verify that it is followed. See the FMEDA[(1)] report for additional details or references.

If the overfill and empty tank protection function cannot be tested by a controlled filling to the response height, a suitable simulation of the level or of the physical measuring effect must be used to make the level sensor respond.

The simulation can be done in three different ways:

- by short-circuiting the probe
- by simulating the distance using the built-in simulation mode
- by performing a loop test

The following proof test is recommended. If an error is found in the safety functionality, the measuring system must be switched out of service and the process held in a safe state by means of other measures. Proof test results and corrective actions taken must be documented at www.emersonprocess.com/rosemount/safety.

4.4.1 Proof test

This test detects approximately 95% of the possible Dangerous Undetected (DU) failures of the transmitter including the sensor element, not detected by the transmitter's automatic diagnostics. Instructions for performing the proof test with the Field Communicator, RRM, or AMS, are available in the Appendix E: Performing Proof Test of the Rosemount 5300 Series Reference Manual (Document No. 00809-0100-4530). Note that prior to this test, the echo curve should be inspected to ensure that no disturbing echoes affecting the measurement performance are present in the tank.

Required Tools: HART host/communicator and mA meter.

1. Bypass the logic solver or take other appropriate actions to avoid false trip.
2. Disable write protection if the function is enabled.
3. Using Loop Test, enter the mA value representing a high alarm current output and verify that the analog current reaches that value using the reference meter.

   This step tests for compliance voltage problems, such as low loop power supply voltage or increased wiring resistance.
4. Using Loop Test, enter the mA value representing a low alarm current output and verify that the analog current reaches that value using the reference meter.

   This step tests for possible quiescent current related failures.

(1) The FMEDA report is accessible at www.emersonprocess.com/rosemount/safety/PriorUse.htm.

5. Perform a two-point calibration check of the transmitter by applying the level to two points on the probe within the measuring range[1]. Verify that the current output corresponds to the level input values using a known reference measurement.

   This step verifies that the analog output is correct in the operating range and that the primary variable is properly configured.

6. Enable write protection.

7. Restore the loop to full operation.

8. Remove the bypass from the safety logic solver or otherwise restore normal operation.

9. Document the test result for future reference.

For troubleshooting the transmitter, see Section 5: Troubleshooting procedures or the Rosemount 5300 Series Reference Manual (Document No. 00809-0100-4530).

For best performance, use the 4 - 20 mA range points as calibration points.

4.4.2 Visual inspection

It is recommended to inspect the probe for possible build-up or clogging.

4.4.3 Special tools

Not required.

4.4.4 Product repair

The Rosemount 5300 Series is repairable by major component replacement. All failures detected by the transmitter diagnostics or by the proof test must be reported. Feedback can be submitted electronically at www.emersonprocess.com/rosemount/safety (Contact Emerson Process Management).

For further information on proof testing, see the Rosemount 5300 Series Reference Manual (Document No. 00809-0100-4530) or contact your local Emerson Process Management representative.

(1) For best performance, use the 4-20 mA range points as calibration points.

Section 5 Troubleshooting procedures

5.1 Safety messages

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Please refer to the following safety messages before performing an operation preceded by this symbol.

⚠ WARNING

Explosions could result in death or serious injury.

Verify that the operating environment of the gauge is consistent with the appropriate hazardous locations certifications.

Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

Do not remove the gauge cover in explosive atmospheres when the circuit is alive.

Failure to follow safe installation and servicing guidelines could result in death or serious injury.

Make sure only qualified personnel perform the installation.

Use the equipment only as specified in this manual. Failure to do so may impair the protection provided by the equipment.

Do not perform any service other than those contained in this manual unless you are qualified.

High voltage that may be present on leads could cause electrical shock.

Avoid contact with leads and terminals.

Make sure the main power to the transmitter is off and the lines to any other external power source are disconnected or not powered while wiring the gauge.

Probes covered with plastic and/or with plastic discs may generate an ignition-capable level of electrostatic charge under certain extreme conditions. Therefore, when the probe is used in a potentially explosive atmosphere, appropriate measures must be taken to prevent electrostatic discharge.

Process leaks could result in death or serious injury.

Make sure that the transmitter is handled carefully. If the process seal is damaged, gas might escape from the tank if the transmitter head is removed from the probe.

⚠ WARNING

Any substitution of non-authorized parts or repair, other than exchanging the complete transmitter head or probe assembly, may jeopardize safety and is prohibited.

Unauthorized changes to the product are strictly prohibited as they may unintentionally and unpredictably alter performance and jeopardize safety. Unauthorized changes that interfere with the integrity of the welds or flanges, such as making additional perforations, compromise product integrity and safety. Equipment ratings and certifications are no longer valid on any products that have been damaged or modified without the prior written permission of Emerson Process Management. Any continued use of product that has been damaged or modified without prior written authorization is at the customer's sole risk and expense.

5.2 Introduction

This section provides information on identifying the most common problems found with radar level transmitters. A typical workflow may look like this (local restrictions and variations may apply):

1. Check voltage at transmitter terminals. Verify that the input voltage requirement is fulfilled, and wiring is correct.
2. View Distributed Control System (DCS) trends and question the relevant people to understand when the problem occurs and the effect of the problem. Could it be related to any other activities?
3. Do a tank survey to identify the application. Ensure that the transmitter has been selected according to Section 1: Power applications, and "Chamber installations" on page 6.
4. Check for basic errors, such as cables and transmitter diagnostics, then complete relevant parts of "Commissioning" on page 35 again.
5. If necessary, execute the verification procedure described in Section 4: Measurement validation, or other procedure that recreates the problem.
6. A) If the measurement is reliable, but there is an offset or the accuracy is poor, refer to "Echo curve analysis" on page 64.

   B) Do an echo curve analysis as described in "Echo curve analysis" on page 64 to try to identify the problem.

When the problem has been resolved, the validation procedure described in Section 4: Measurement validation should be completed, or any other procedure that verifies the integrity of the transmitter. If the problem cannot be resolved, contact your local Rosemount representative for assistance with a description of the problem and application, also be able to submit the echo curve (.dat) and the transmitter backup file (.bak), taken at present conditions and during commissioning.

5.3 Diagnostics

Basic rules and philosophy about the diagnostic messages is that the transmitter will generate an alarm current if the diagnostic message indicated is a "device error" or a "lost measurement" alarm.

If the transmitter is not generating an alarm current, but there are one or more diagnostic messages, the transmitter is working properly, and the messages are more measurement information, device warnings/status type of messages. For a FOUNDATION™ fieldbus device, the above information is the same, but for a FOUNDATION fieldbus device there is no alarm current, instead it is reflected through a "Bad" status of the measurement value.

Some diagnostic messages are sequential diagnostic messages, generated because another diagnostics is active. In the device itself, the diagnostics is split into different categories:

- Device status
- Device errors
- Device warnings
- Measurement status

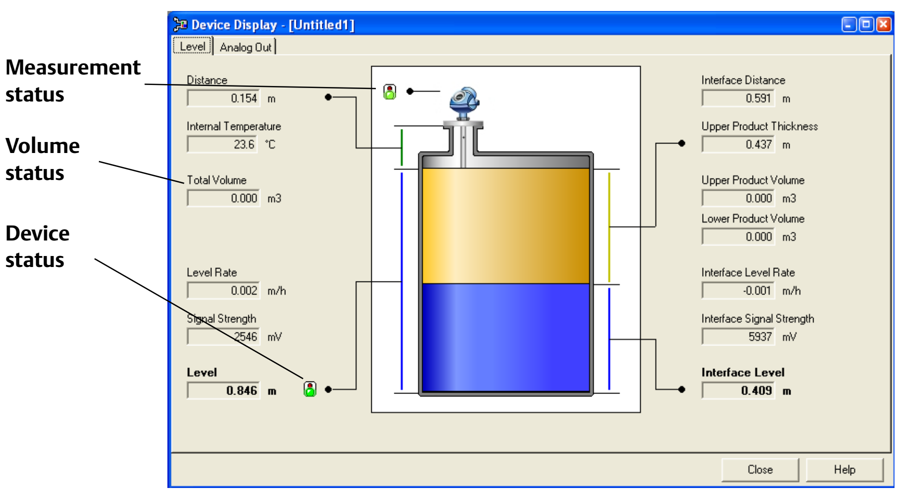
Specific status messages related to specific topics, such as:

- Volume calculation status
- Analog output status (HART only)

These categories are displayed in different ways across the different configuration tools. Refer to the product-related reference manuals for details.

In Rosemount Radar Master (RRM), the main diagnostics is presented in the Tools menu, but diagnostics is also presented in other places such as the Device Display window.

Figure 5-1. Diagnostics in the Device Display window



RRM > Tools > Device Display

RRM > Tools > Diagnostics

5.4 Echo curve analysis

The echo curve represents the tank, as seen by the radar transmitter. Each peak corresponds to a reflection of the radar signal - the surface of the level, an obstacle, or something else. By viewing single instances or movies of the echo curve, how and why the transmitter behaves as it does can be understood, and it can be configured accordingly to achieve a reliable level measurement. Usually, an echo curve analysis is not needed; the transmitter automatically sets the appropriate parameters based on the start-up information, such as tank height, and tank media, etc. However, it is a very valuable tool for troubleshooting difficult applications.

5.4.1 Echo curve constituents

Figure 5-2. Echo curve presentation in RRM

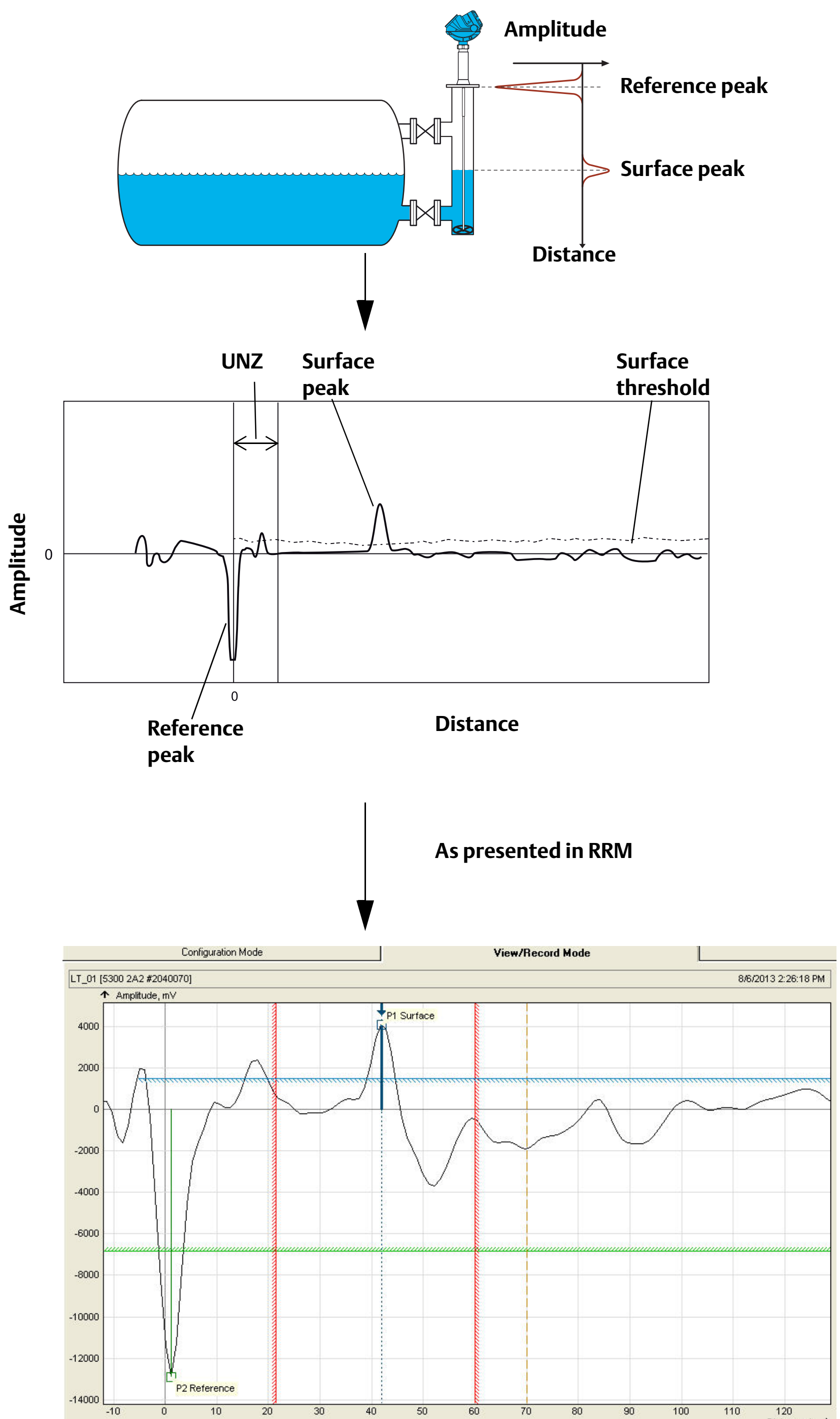
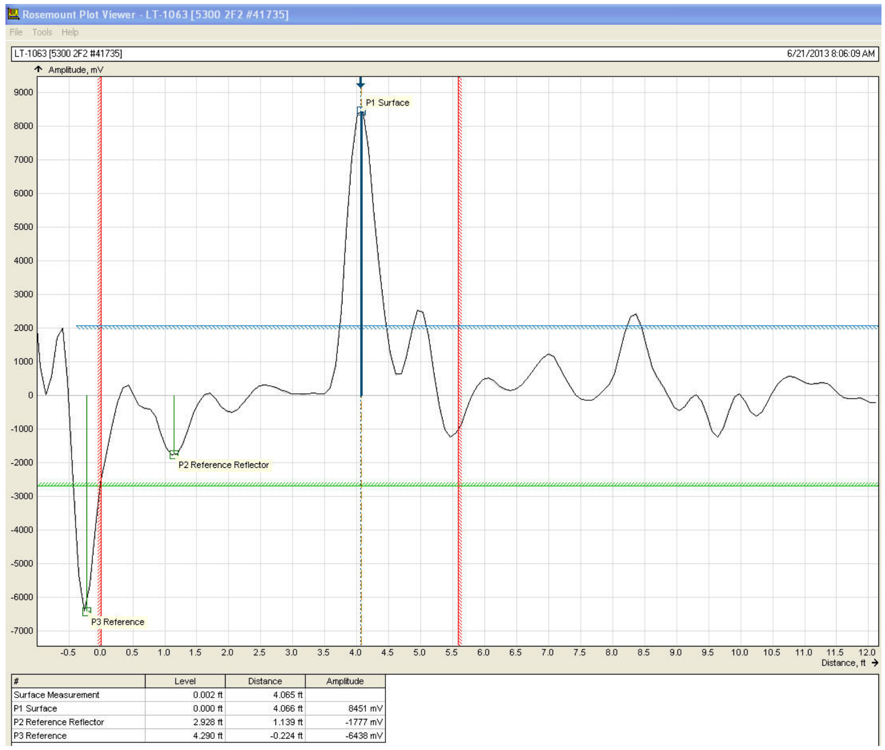


Figure 5-3. Rosemount 5300 Series with DVC - Echo curve presentation in RRM



In a typical measurement situation, the following peaks appear in the echo curve:

Reference peak. This reference pulse is caused by the transition between the transmitter head and the probe/antenna. For the Rosemount 3300 and 5300 Series, the pulse is negative, while for the Rosemount 5400 and 5600 Series, the pulse is positive, see Figure 5-6 on page 68. For Rosemount 5301 with DVC, the seal pulse is used as reference. See Table 5-2 on page 67 for the typical reference pulse amplitudes for the Rosemount 5300 Series.

Reference reflector peak (Rosemount 5300 with DVC only). This reference reflector pulse is caused by the transition between reference reflector and continuing part of the probe. The pulse is negative, but not as strong as the reference pulse. In RRM, it should be labelled as P2 other or P3 other (if surface echo/centering disk is present) after vapor compensation is calibrated, see "Commissioning" on page 35. The amplitude of the reference reflector peak is dependent on the installation (chamber diameter) and the process conditions of the application. See also Figure 4-5 on page 55.

Surface peak. This pulse is caused by a reflection of the product surface. See Table 5-1 for typical surface peak amplitudes for the Rosemount 5300 Series. Note that the amplitude is dependent on the dielectric constant of the media, transmitter type, probe/antenna type, process conditions (vapor, turbulence, foam etc.), distance to echo, etc.

Probe end peak. This probe end pulse is caused by the transition between the probe end and the surrounding media. The pulse can be positive or negative depending on if or what type of centering disk is used, see Figure 5-4 and Figure 5-5. Note that the probe end pulse is not visible when measuring on a high dielectric media, such as water.

Table 5-1. Typical peak amplitudes for the Rosemount 5300 Series with a single lead probe in 4 in. (100 mm) chambers

Peak	Approximate signal strength, ideal conditions for single lead probe in 4 in. (100 mm) chambers
Reference peak	~10,000 mV(1)
Surface peak, Rosemount 5301 with oil (DC=2)	~2,000 mV
Surface peak, Rosemount 5301 with water (DC=80) at 3 ft (1 m) distance	~10,000 mV

(1) This value does not apply and may be considerably lower when the probe is completely submerged in product, or in applications with saturated steam or heavy condensation.

Table 5-2. Typical reference pulse amplitudes for the Rosemount 5300 Series with different probe types.

	Single Probe	Coaxial Probe
Standard Seal	~12000-16000 mV(1)	~6000 mV(1)
HP/HTHP Seal	~9000-11000 mV(1)	~5000-7000 mV(1)

(1) This value does not apply and may be considerably lower when the probe is completely submerged in product, or in applications with saturated steam or heavy condensation.

Rosemount 5300 Series probe end pulse

Figure 5-4. A PTFE centering disk or a free hanging probe end give a negative probe end pulse

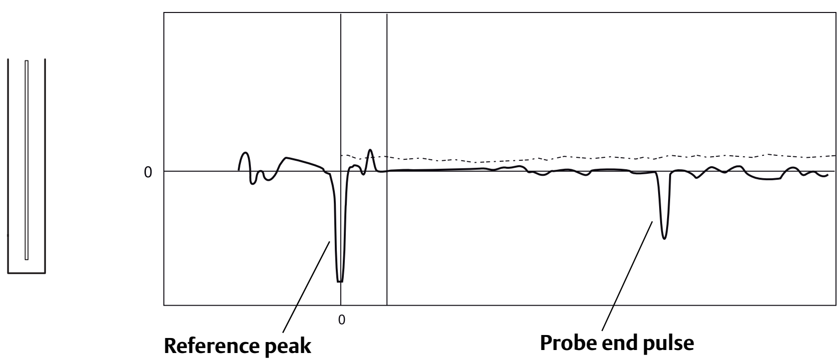
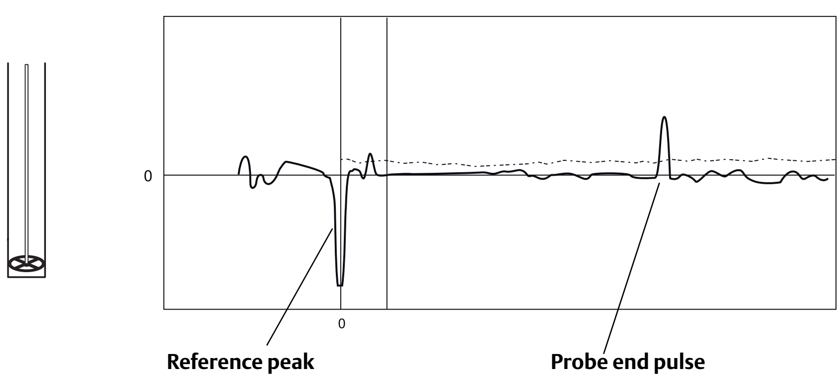


Figure 5-5. A stainless steel centering disk gives a positive probe end pulse



Rosemount 5400 and 5600 Series

Various amplitude thresholds are used to filter out unwanted signals and pick up the different peaks. The transmitter uses certain criteria to select which peaks correspond to the actual level surface.

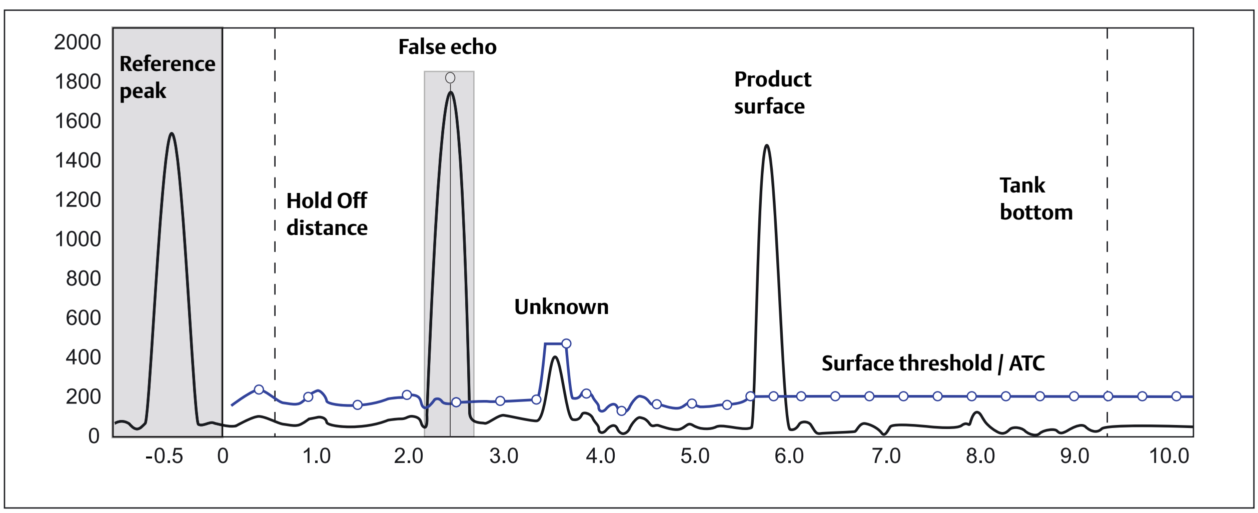
For GWR transmitters counting from the top of the tank, the first echo above the surface threshold is considered the product surface. Pulses further away from the top, although above the surface threshold, are ignored. Non-contacting radar transmitters use other certain criteria to decide which type of pulse that is detected. Echoes found above the surface threshold might be considered the product surface.

Surface threshold. This is the amplitude threshold for detection of the product level peak. The surface threshold is designed as a number of individually adjustable amplitude threshold points, the ATC.

Upper Null Zone / Hold Off distance. Measurements are not performed within the UNZ / Hold Off distance, consequently, the UNZ / Hold Off can be used to avoid measurements above a certain level, for example because of disturbances in the nozzle. For GWR, TNZ is the preferred choice for handling disturbances in the near zone, since measurement is still possible in near zone, see “Trim Near Zone (GWR transmitters)” on page 37 for activation.

False echo area (Rosemount 5400 Series only). False echo areas are set during the Measure and Learn function, when the disturbing object is larger than the surface echo, see Figure 5-6. The false echo area can be adjusted manually. See the Rosemount 5400 Series Reference Manual (Document No. 00809-0100-4026) for details.

Figure 5-6. Rosemount 5400 and 5600 Series echo curve presenting all visible echoes



5.4.2 Rosemount GWR transmitter threshold settings

Recommendations for the Rosemount 3300 and 5300 Series:

1. Use the automatic threshold settings and ensure that the dielectric constants of the vapor and products have been entered correctly
2. If needed, apply the Measure & Learn function
3. If needed, use the following best practices to apply custom threshold adjustments:
   - Generally, the threshold should be at 40-50% of the surface peak. Example: If the surface is 2000 mV, the threshold should be set at 800-1000 mV
   - It should never be closer than 300 mV to any disturbing objects. Example: If there is a 1100 mV peak from an inlet-pipe, the threshold around it should be 1400 mV
   - The threshold should never be below 800 mV in the range 0-1 ft (0.3 m) and never below 500 mV from 1 ft (0.3 m) upwards

For products with very low dielectric constants, such as solids, it may be required to lower the threshold additionally, and/or to activate the PEP function. See "Probe End Projection (Rosemount 5300 Series solids measurement)" on page 48 for the activation of PEP.

5.4.3 Rosemount non-contacting radar transmitter threshold settings

Recommendations for the Rosemount 5400 and 5600 Series:

1. Apply the Measure & Learn function (Rosemount 5400 Series only)
2. If needed, use the following best practices to apply custom threshold adjustments:
   - Generally, the threshold should be at 20% of the surface peak.
     Example: if the surface is 2000 mV, the threshold should be set at 400 mV
   - It should never be closer than 200 mV to any disturbing objects.
     Example: if there is a 500 mV peak from an obstacle, the threshold around it should be 700 mV
   - The threshold should never be below 300 mV

For products with very low dielectric constants, such as solids, it may be required to lower the threshold additionally. For the Rosemount 5600 Series, manual adjustments are always recommended.

5.4.4 Common problems

Threshold below the surface peak

In this example, the threshold has incorrectly been set above the surface peak, see Figure 5-7. The problem can be corrected by lowering the threshold, see Figure 5-8.

Figure 5-7. Surface peak is below the surface threshold

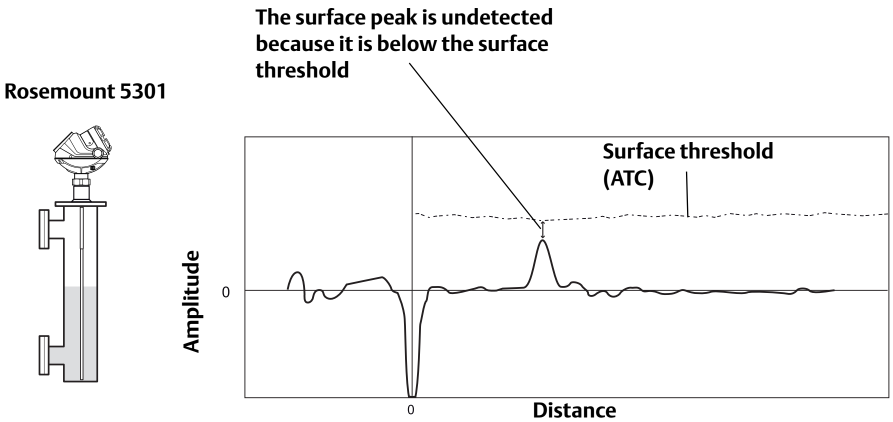
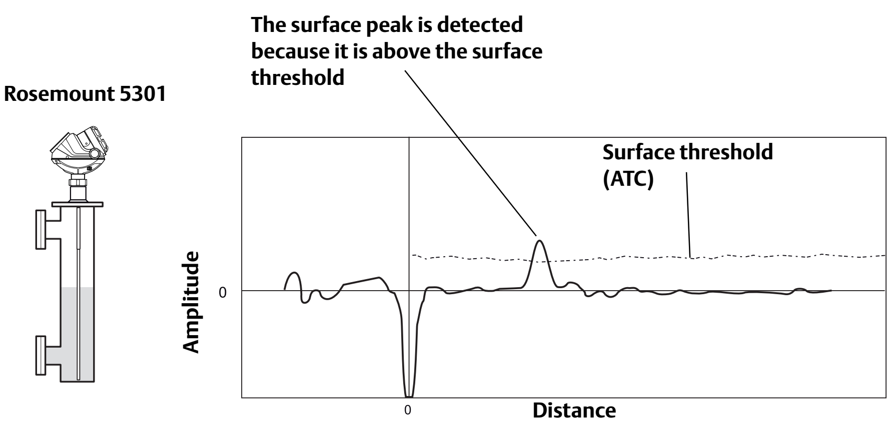


Figure 5-8. Surface peak is above the surface threshold



Disturbance misinterpreted as level

In this example, the transmitter incorrectly identifies the reflection from an inlet-pipe as the product surface, because it is the first peak above the surface threshold, see Figure 5-9. Tall, narrow, and/or rough nozzles can also create disturbance echo in the form of double bounces. The double bounce will always appear at twice the disturbance distance. Ensure that the recommendations in Section 2: Installation considerations are followed. The problem can be solved by increasing the surface threshold (see Figure 5-10) or, in some cases where the disturbance is close to the transmitter flange, by increasing the UNZ or performing the 'Near Zone Trim' command.

Figure 5-9. The surface is the reflection from the inlet-pipe

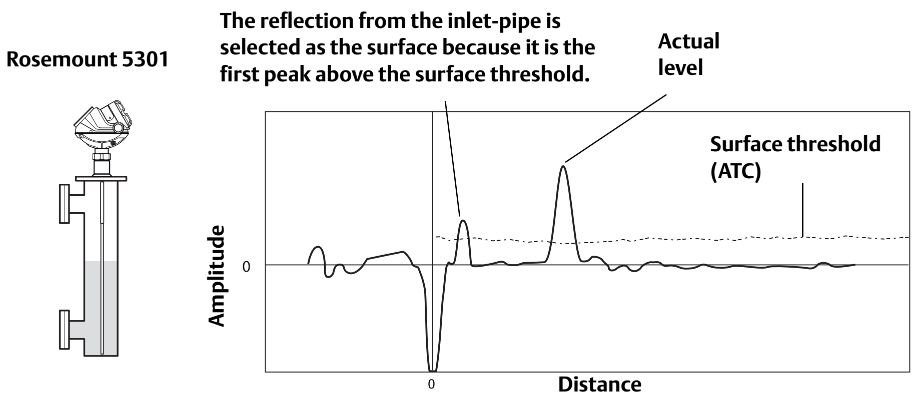
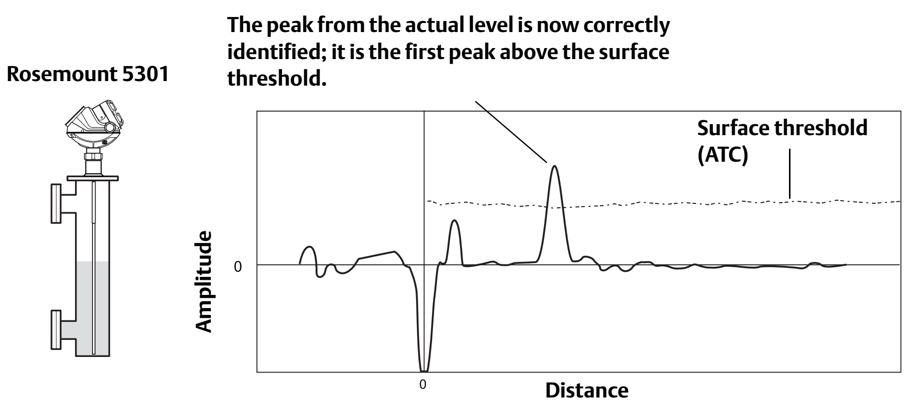


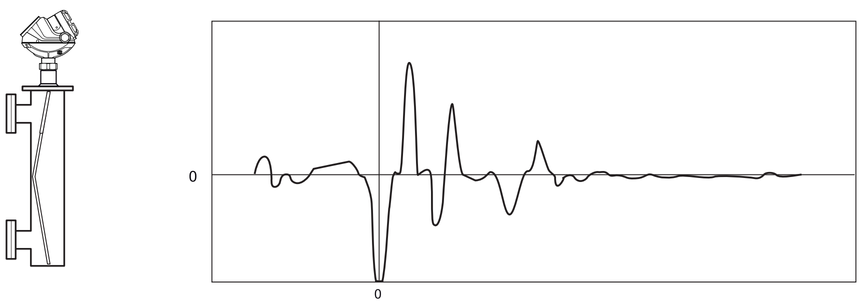
Figure 5-10. Surface peak identified correctly



Incorrect reading due to bent probe or probe contacting the nozzle wall

A bent, twisted probe (in the case of flexible probes) in contact with metal creates a strong echo that the measurement will lock onto, see Figure 5-11. If this is the case, the mechanical installation will need to be redone ensuring that the recommendations in Section 2: Installation considerations are followed. The probe length should match the tank/chamber length or be slightly shorter. The problem can often be resolved by adding a centering disk at the bottom of the probe, but it may also require a replacement of the complete probe assembly.

Figure 5-11. Measurement data using a bent probe

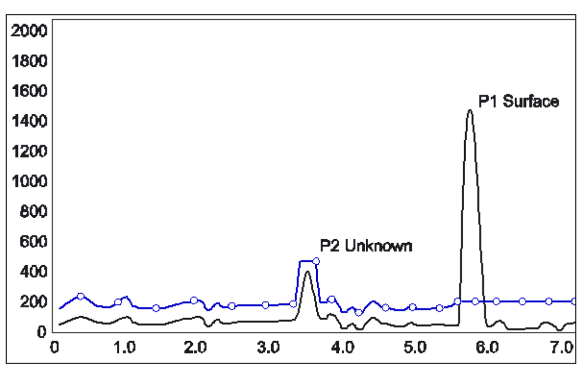


Possible build-up on probe

If it is a normal but strong echo noise from process or tank environment (i.e. inlets, nozzle, etc.), perform the Trim Near Zone function. If necessary, adjust the surface threshold (manually or by Measure & Learn), and also consider using a coaxial probe.

If the echo is due to contamination, the probe should be cleaned. If SQM is used, the values of measurement margin and signal quality can be used to monitor build-up. If SQM is not available, the secondary variable can be set to signal strength to foresee the need of cleaning. The threshold can also be raised if the surface peak is strong enough. Finally, consider insulating the chamber to minimize risk of build-up.

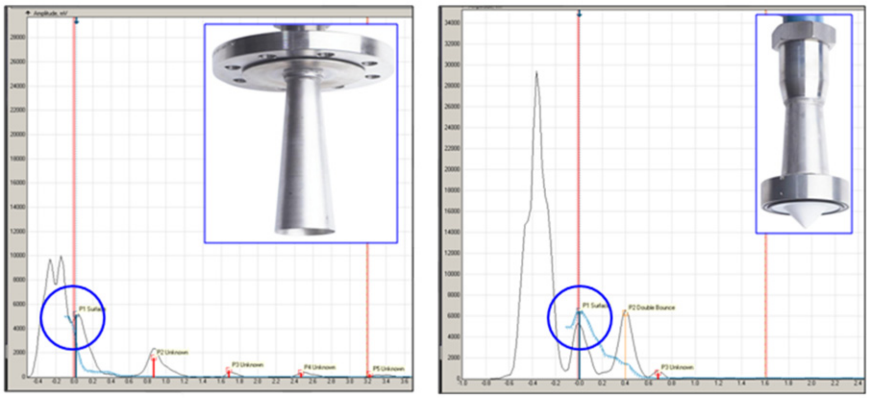
Figure 5-12. Build-up on probe



Strong antenna echo and weak surface echo

Water condensation in a cone antenna or build-up on a process seal window will create a strong echo from the antenna and a weak surface echo. Examine installation and adjust Hold-Off and surface threshold if the surface echo is still strong enough. Insulating the nozzle generally reduces the condensation or build-up. This is because it minimizes the temperature disparity between the internal and the ambient temperature.

Figure 5-13. Strong antenna echo and weak surface echo



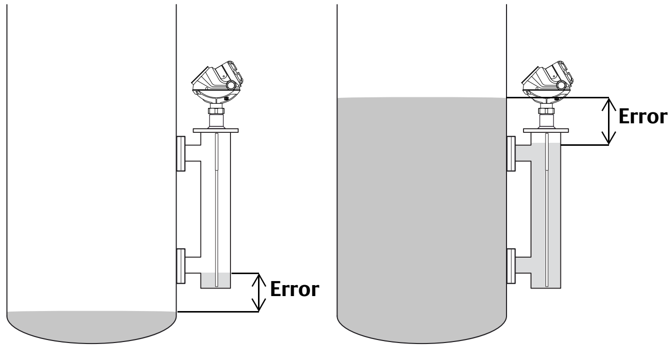
5.5 Sources of measurement error

This section applies to radar level transmitters that track the surface, but have poor accuracy or a fixed offset. There are many possible error sources for this, such as incorrect settings or incorrect interpretation of the analog output signal. These errors almost exclusively depend on the external environment since radar is extremely accurate and does not drift.

5.5.1 Installation and location errors

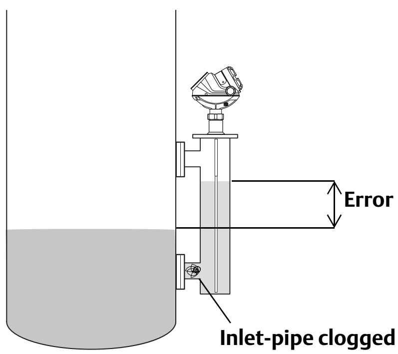
Review the installation to determine what the transmitter is measuring and what the expected output is. In a chamber installation, check that the level corresponds to the value inside the tank. Ensure that the chamber has been installed where the level range can be adequately covered.

Figure 5-14. Installation error - level/interface range is not covered adequately



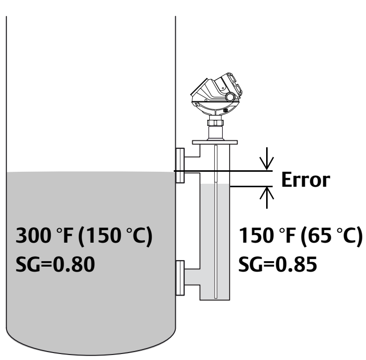
The connections between the vessel and the chamber must allow for flow of the product. Clogging should be avoided.

Figure 5-15. Inlet-pipe clogged



The radar transmitter is not temperature-dependent. However, the fluid is, and it expands and contracts with increased and decreased temperatures. With certain fluids, the effect on level is noticeable in hot applications with large differences in temperature between the chamber and the tank. Insulating the chamber minimizes the temperature changes. This is especially important for applications with saturated steam, since the radar measurement is dependent on the dielectric properties of the steam. See "Incorrect static vapor compensation" on page 78 for details.

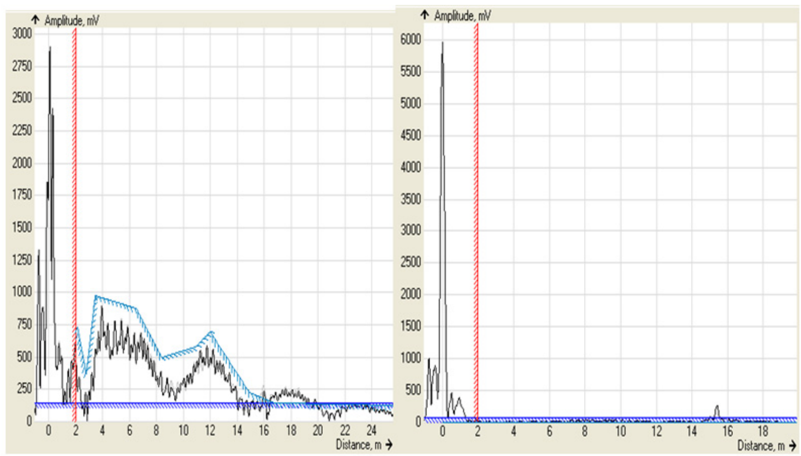
Figure 5-16. Temperature drop in the chamber without insulation



Rosemount 5600 Series solids measurement

In a nozzle installation, review the installation considerations. For solids measurement with weak surface echo, mechanical installation is especially important, since nozzle disturbances will disrupt the surface measurement. For best practice, ensure that the antenna reaches into the tank (at least 2 in. (50 mm)). If necessary, review threshold settings and adjust hold-off (UNZ).

Figure 5-17. Mechanical installation - What difference does it make?



Antenna recessed up in nozzle/manway

Level is at 52 in. (16 m)

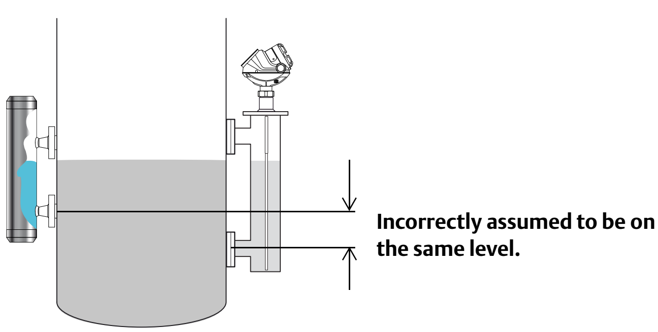
Antenna reaches into tank

Level is still at 52 in. (16 m), but now visible

5.5.2 Geometries

Review the tank geometry and check if any assumptions have been made that caused the inaccuracies. For example, the location of a sight-glass or secondary chamber may have been assumed to be at the same location as the radar measurement, but in reality they are not.

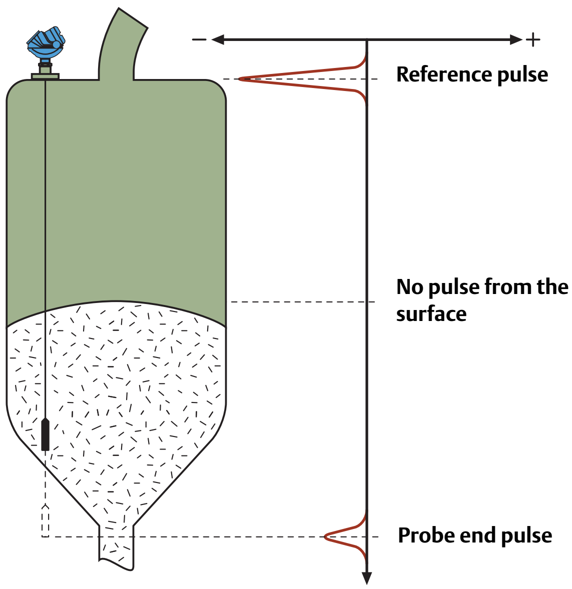
Figure 5-18. The sight-glass and chamber are not on the same level where they are supposed to be



5.5.3 Probe End Pulse offset (only relevant for PEP)

An offset of the probe end pulse is normal if there is product in the vessel. However, it can also be caused by mis-configured probe length. Ensure that correct probe length is configured by emptying the tank and reading the probe end pulse or measuring the probe. Also ensure that PEP in "Probe End Projection (Rosemount 5300 Series solids measurement)" on page 48 has been followed.

Figure 5-19. Probe end pulse offset



5.5.4 Analog output settings

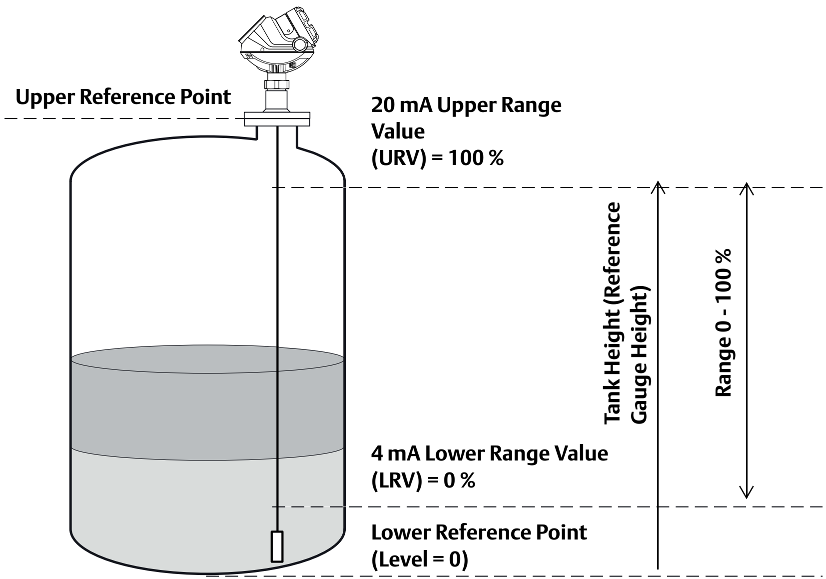
Review the analog output settings. The primary variable determines the output, and is often set to level. The definition is:

Level = tank height (reference gauge height) - measured distance

Consequently, the zero level point is at tank height (reference gauge height), below the transmitter's flange. The LRV (4 mA setpoint) and URV (20 mA setpoint) should be set with this zero point as reference.

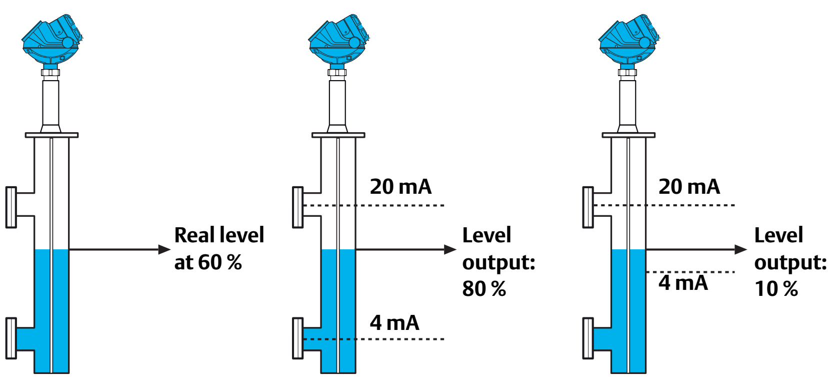
Probe length and tank height (reference gauge height) do not need to match.

Figure 5-20. Analog output settings - range values and reference points



The analog output depends on how the range values are set, see Figure 5-21 for examples.

Figure 5-21. Analog output settings



5.5.5 Incorrect static vapor compensation

Specific high-temperature and high-pressure applications, like those with saturated steam vapors, require that a compensated value be entered for the vapor dielectric constant. This compensation is fixed and will only adjust the level reading at a specific condition. Normally, this means that the transmitter will show a correct level reading during operation, but not during startup and shutdown. Alternatively, if no correction is entered, the level reading will be correct during shutdown, but not during startup and operation (see Table 5-3 and Table 5-4).

Table 5-3. Properties of water and saturated steam

Temp. °F/°C	Pressure psia/bar	DK of liquid	DK of vapor	Error in distance %
100/38	1/0.1	73.95	1.001	0.0
200/93	14/1	57.26	1.005	0.2
300/149	72/5	44.26	1.022	1.1
400/204	247/17	34.00	1.069	3.4
500/260	681/47	25.58	1.180	8.6
600/316	1543/106	18.04	1.461	20.9
618/325	1740/120	16.7	1.55	24.5
649/343	2176/150	14.34	1.8	34.2
676/358	2611/180	11.86	2.19	48
691/366	2900/200	9.92	2.67	63.4
699/370	3046/210	8.9	3.12	76.6
702/372	3118/215	Above critical point, distinct liquid and gas phases do not exist.		

Table 5-4. Level reading errors during shutdown, with fixed saturated water steam correction activated

Entered Vapor DC	Error in reading, when actual Vapor DC is 1 (corresponding to water at room temperature)		Offset in reading, if Vapor DC is configured correctly
	Surface at 15 in (380 mm) from flange	Surface at 30 in. (760 mm) from flange	
1.001	0 in. (0 mm)	0 in. (0 mm)	0 in. (0 mm)
1.022	0.2 in. (4 mm)	0.3 in. (8 mm)	0 in. (0 mm)
1.180	1.3 in. (33 mm)	2.6 in. (65 mm)	0 in. (0 mm)

NOTE:
When performing verification at ambient pressure and temperature conditions, always set vapor dielectric to 1. Otherwise level reading will be incorrect.

To set the Vapor Dielectric constant in RRM:

RRM > Tank > Environment

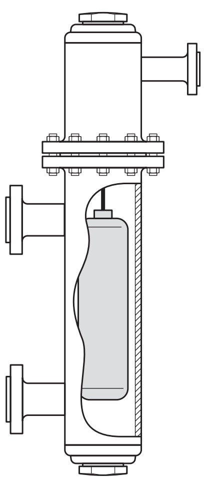
5.5.6 Reconciling radar with other level measurements

When comparing level measurements to each other, they often do not match up as expected. There are numerous reasons for this with the most prominent one being related to what is actually being measured. Few instruments measure the level directly as radar does. Instead an indirect measurement of, for example, pressure, weight, or capacitance is done, and then the level is calculated from this measurement. Inaccuracies in the level measurement may occur during the calculation process, or from the fact that what is thought to be the measurement is not what is actually being measured.

Displacer

Displacers are a common method to measure level. The Archimedes principle is used, and by measuring the apparent weight of the immersed displacer, the level can be measured indirectly. Beside the possibility of the displacer getting stuck, it also requires precise calibration. Any change in density, such as a different product in the tank or changed temperature, will result in inaccuracies.

Figure 5-22. Displacer used for measurement



Example

A 50 in. (1270 mm) displacer calibrated to SG 0.9 will only show a 45 in. (1143 mm) level reading at full range with a product that has a SG 0.8. This results in a systematic error of 45 - 40 = 5 in. (127 mm).

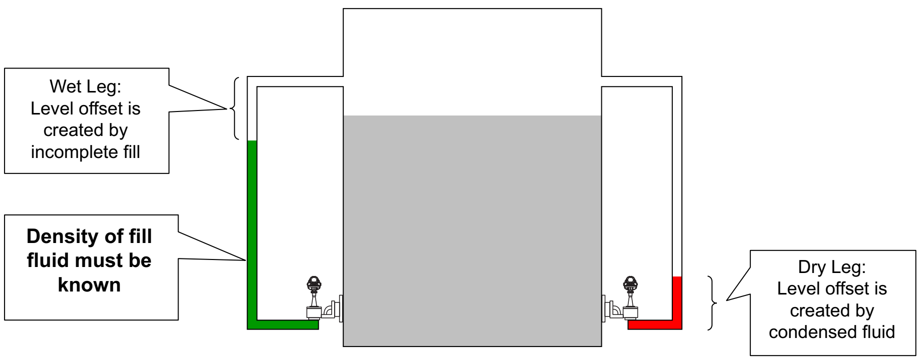
Differential pressure

Another common method for measuring level is using pressure or Differential Pressure (DP) transmitters. These are examples of indirect level measurement methods, where incorrect conversion or installation can result in inaccuracies.

Potential problems include:

- **Fluid density changes:** source, grade, product and temperature affect the density of the fluid, and thereby the level output.
- In case of a **wet leg**, is it completely filled? Or, if a dry leg is used, is it really dry? Loss of fluid and condensed fluid respectively create an offset in the level reading. Consider using either an electronic or a capillary remote seal.
- If a **fill fluid** is used, is its density known? Has the transmitter been scaled correctly?
- If a single pressure transmitter is used, process pressure will create an offset in the level reading. A differential pressure transmitter should be used.

Figure 5-23. Differential pressure transmitter



Appendix A Checklists

A.1 Safety messages

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Please refer to the following safety messages before performing an operation preceded by this symbol.

⚠ WARNING

Explosions could result in death or serious injury.

Verify that the operating environment of the gauge is consistent with the appropriate hazardous locations certifications.

Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.

Do not remove the gauge cover in explosive atmospheres when the circuit is alive.

Failure to follow safe installation and servicing guidelines could result in death or serious injury.

Make sure only qualified personnel perform the installation.

Use the equipment only as specified in this manual. Failure to do so may impair the protection provided by the equipment.

Do not perform any service other than those contained in this manual unless you are qualified.

High voltage that may be present on leads could cause electrical shock.

Avoid contact with leads and terminals.

Make sure the main power to the transmitter is off and the lines to any other external power source are disconnected or not powered while wiring the gauge.

Probes covered with plastic and/or with plastic discs may generate an ignition-capable level of electrostatic charge under certain extreme conditions. Therefore, when the probe is used in a potentially explosive atmosphere, appropriate measures must be taken to prevent electrostatic discharge.

A.2 Checklists

A.2.1 Commissioning procedure

Step	Task	Completed
1	System readiness is confirmed (Rosemount 5300 and 5400 Series only) a. HART revision capability is checked b. The latest Device Driver is downloaded c. HART revision mode is switched (if the HART configuration tool is not capable of communicating with the HART Revision 7 protocol)	☐
2	The transmitter head and probe/antenna are mounted as written in the respective Quick Installation Guide (QIG)	☐
3	Wiring is connected as written in the QIG a. Wiring and power supply requirements are according to the approval certifications b. A conditioned power supply and terminating resistors are available (for Foundation fieldbus devices) c. Shielded twisted pair wiring is used d. Grounding is completed according to the Hazardous Locations Certifications, national and local electrical codes	☐
4	Transmitter is connected as written in the QIG	☐
5	Transmitter is configured as written in the QIG	☐

A.2.2 Measurement validation procedure

Step	Task	Completed
1	The transmitter is in operation	☐
2	Level reading correctness is verified a. The transmitter level reading is compared with an independent measurement	☐
3	The analog output signal is validated (for 4-20 mA/HART units only) a. Loop is set to manual mode in the Distributed Control System (DCS) b. Transmitter is in simulation mode (accessed in RRM) c. Loop test function is activated d. Arbitrary level readings are created at 4, 12, and 20 mA e. The arbitrary level readings and the readings in the DCS match	☐
4	Echo-curve is verified a. Reference pulse amplitude and position are checked b. Peak amplitudes are checked c. Thresholds are set according to the Reference Manual d. Echo-curve is stored	☐
5	Transmitter diagnostics is reviewed	☐
6	Level is monitored while emptying the tank a. Log functionality for the transmitter level output is activated b. Process valves are closed before draining (for chambers only) c. The tank or chamber is emptied completely d. Level trend is reviewed for accuracy	☐
7	Echo-curve is verified with empty tank a. Echo-curve is compared with previous plots b. Echo-curve is stored	☐
8	Level is monitored while filling the tank a. Log functionality for the transmitter level output is activated b. Process valves are closed before filling (for chambers only) c. The tank or chamber is filled completely d. Level trend is reviewed for accuracy	☐

A.2.3 Troubleshooting procedure

Step	Task	Completed
1	Voltage at transmitter terminals are checked	☐
2	DCS trends are checked	☐
3	Tank survey is done to identify the application	☐
4	Basic errors (cables, transmitter diagnostics etc.) are checked a. Cables are connected properly b. Diagnostic messages are checked (in RRM)	☐
5	Verification procedure is executed, if necessary (as described in the measurement validation procedure)	☐
6	Echo-curve analysis is performed and analyzed	☐
7	Threshold settings are checked (Rosemount 3300 and 5300 Series) a. Automatic threshold settings are used b. Dielectric constants are entered correctly c. Measure & Learn function is applied (if necessary) d. Custom threshold adjustments are applied	☐
8	Threshold settings are checked (Rosemount 5400 and 5600 Series) a. Measure & Learn function is applied b. Custom threshold adjustments are applied	☐
9	Echo-curve is checked for common problems a. Threshold is below the surface peak b. Disturbance is misinterpreted as level c. Incorrect reading due to bent probe d. Incorrect reading due to probe contacting the nozzle wall e. Possible build-up on probe f. Strong antenna echo g. Weak antenna echo	☐
10	Sources of measurement errors are checked a. Installation and location errors b. Tank geometry c. Probe End Pulse offset (only for Probe End Projection) d. Analog output settings e. Incorrect static vapor compensation f. Reconciling radar with other level measurements g. Chamber measurement	☐
11	Measurement validation procedure is completed to verify the transmitter's integrity	☐

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